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A Monograph of the Genus *Taphrina*

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ABSTRACT: The genus *Taphrina,* founded by Fries in 1832 on the species *Taphrina populina,* is the only recognized genus in the family Taphrinaceae, order Taphrinales of the Ascomycetes.

All species of the genus are parasitic on higher plants or ferns, forming mycelium (*a*) intercellularly; (*b*) subcuticularly; or (*c*) within the epidermal wall; forming asci in a subcuticular layer or in a wall locule; overwintering in the form of blastospores derived from ascospores by budding or in a few species as perennial mycelium. Infection (so far as known) is by blastospores.

Asci arise from rounded ascogenous cells (chlamydospores), either by elongation of the ascogenous cell or by bursting out from the ascogenous-cell wall. In many species a stalk cell (basal cell) is cut off from the ascus proper. Budding of the ascospores to form blastospores may occur within the ascus and continues after spore expulsion.

Mycelium is dicaryotic. Fusion of nuclei occurs in the ascogenous cell; meiosis in the young ascus. In one species (*T. epiphylla*) conjugation of ascospores (or blastospores) occurs, resulting in dicaryotic hyphae. In other species (so far as known) the dicaryotic condition is attained by division of the single nucleus of the blastospore.

Species of *Taphrina* grow readily in artificial media if cultures are originated from ascospores or blastospores; behaving in media as yeasts. Cells formed in culture are blastospores, hyphae, ascogenous cells, and (rarely) asci.

Ninety-eight species of *Taphrina* are here redescribed and redefined (other species being reduced to synonymy or excluded). These are distributed by hosts as follows: On Ferns, 24 species; on *Populus* and *Salix,* 4; on *Betulaceae,* 23; on *Fagaceae,* 5; on *Ulmaceae,* 2; on *Rosaceae* (except *Prunus*), 7; on *Prunus,* 17; on *Rhus,* 1; on *Acer,* 11; on *Aesculus,* 1; on *Sebastiana,* 1; on *Zingiberaceae,* 2.

INTRODUCTION

IN earlier papers on the genus *Taphrina* an account of important literature (Mix, 1936) and a list of presumably valid species (Mix, 1936a) was presented. Since this species-list was compiled from the literature and was not based on the study of actual specimens, its value could be only temporary.

Following publication of these papers, morphological studies[1] have been completed of all known species of *Taphrina,* and it is now possible to undertake a thorough revision of the genus.

In certain cases the results of inoculation-experiments would be helpful in reaching decisions on the identity of species, but for the most part delimitation of species can be made on morphological grounds. Interesting as biologic relationships will prove, their elucidation is not likely to result in either combination or division of morphologically evident species. Therefore, although many species of *Taphrina* have been obtained in culture, and host relationships are being studied by means of inoculations, it seems unnecessary to await the results of these studies before proceeding to a revision of the genus.

The present paper gives an account of all known species of *Taphrina.* It is proposed to treat these species by host groups, discussing first species occurring on ferns and then those on Dicotyledons and Monocotyledons, following the taxonomic arrangement of host genera. For nomenclature of woody plants Rehder's Manual of Cultivated Trees and Shrubs has been consulted. Other higher plants have been named in agreement with Index Kewensis and ferns in accordance with the usage of the Gray Herbarium.

In this revision an effort has been made to disturb existing situations as little as possible, especially as regards division of species and erection of new species therefrom. In some cases description of new species has seemed unavoidable, and, on the other hand, it has sometimes seemed necessary to combine two or more existing

1. These studies were made, for the most part, during the period 1935-1940. They were aided by mycologists the world over who sent valuable specimens as loans or gifts. Space will not permit naming all of these collaborators but grateful acknowledgment to them is hereby made.

Thanks are due also to the Chancellor and Board of Regents of the University of Kansas for leave granted in 1939-1940, to Dr. Carl Hammarlund for laboratory facilities at Statens Växtskyddanstalt, Stockholm; to Dr. Th. Arwiddson for working privileges at the Botaniske Riksmuseum, Stockholm; and to Dr. L. M. Massey for a temporary appointment in the Department of Plant Pathology, Cornell University, during the winter, spring, and summer of 1940.

The late Dr. D. H. Linder was so kind as to make available the facilities of the Farlow Herbarium during the autumn of 1939.

species into one. Many species of *Taphrina* have in the past been described as new without due regard to existing species. In some cases occurrence on a new host was considered sufficient reason for erecting a new species. In other cases morphological peculiarities described by the author of a species have been found to disappear when a number of specimens are examined. Finally, in a few instances, species were hastily and inaccurately described.

In determining the validity of species the principle followed has been to treat as identical those forms that are morphologically similar and occur on related hosts. This is considered sound procedure even when biological distinction is known to exist between different host-forms. The well known treatment accorded the rust fungi by workers within that group may be cited in defense of this point of view.

In critical cases type specimens have been examined. This has not been thought necessary in the case of old and well established species, much studied by earlier authors, such as *Taphrina populina, T. deformans, T. pruni.* Whenever possible study of the type specimen has been supplemented by examination of a number of additional specimens, which has invariably resulted in widening the limits of ascus-size given by the original authors. Often a similar correction has resulted from the study of the type specimen itself.

The species descriptions, then, presented in this paper are in most cases revisions of the descriptions given by the original authors, and, being based on the study of as many specimens as possible, may be accepted as accurate descriptions of the fungi concerned insofar as they are known.

Morphological features considered in delimiting species are those used by all previous investigators: habit of mycelium (whether intercellular, subcuticular, or growing within the host-cell wall), shape and size of asci, presence or absence of a stalk cell, shape and size of stalk cells, and (rarely) size of spores.

CHARACTER OF THE GENUS AND RELATIONSHIPS

The order *Taphrinales* (*Exoascales*) of the Ascomycetes is commonly held to contain but one family, the *Taphrinacae (Exoascacae)* Gaümann (1926) includes a second family, the *Protomycetaceae,* with two genera: *Protomyces* and *Taphridium.* All members of the *Protomycetaceae* are parasitic, causing galls within the tissues of higher plants.

Species of *Protomyces* form in the tissues of their hosts large, round, thick-walled, overwintering chlamydospores. Such a chlamy-

dospore germinates in the spring, its outer wall rupturing and the inner thin-walled cell emerging as a sporangium (ascus or synascus). In the peripheral cytoplasm of the sporangium numerous nuclei divide by meiosis (Büren, 1915), each producing a tetrad of spore mother cells, which by further division form the spores. Spores, after expulsion, conjugate in pairs.

The genus *Taphridium* differs from *Protomyces* in that the chlamydospores are formed in a continuous layer beneath the host epidermis. All known species of *Taphridium* were originally described as species of *Taphrina* (*Magnusiella*).

In the family *Taphrinacae* one valid genus (*Taphrina*)[2] is known. The type species is *Taphrina populina* Fries. Fries first (1815) called this fungus *Taphria populina aurea* and subsequently (1825) changed the genus name to *Taphrina,* stating that *Taphria* had been used as an insect name. In *Systema Mycologicum* (1832), Fries used the name *Taphrina populina* for this fungus.

All known species of *Taphrina* are parasitic, though susceptible (so far as investigated) of artificial cultivation in the asexual stage (Klebahn, 1923, Mix, 1924, Wieben, 1927)[3]. Cultures may be initiated by ascospores[4] or by blastospores derived from them. Slow growing, yeast-like, pale pink colonies are formed on various media and cultures can apparently be propagated indefinitely. Cells formed in culture are chiefly blastospores (yeast cells or bud-conidia), though occasionally short hyphae may be observed, and thick walled "resting cells" are common. These "resting cells" are believed by the writer (Mix, 1924, 1935) to be ascogenous cells like those formed beneath the cuticle of the host. Martin (1940), not finding binucleate "resting cells" in her cultures, believed them to be vegetative cells. In old cultures dicaryotic hyphae (like those in host tissues) may occur, as well as ascogenous cells with fusing nuclei, and even imperfectly formed asci. (Mix, 1935.) Roberts

2. Other genera have been recognized: *Ascomyces, Exoascus, Magnusiella,* but since the papers by Johanson (1886) and Giesenhagen (1895, 1901) the common practice has been to unite these all into one genus, for which the name *Taphrina* has priority. A full account of the use of these different generic names by various authors has been given earlier (Mix, 1936).

3. Following the discovery by Klebahn (1923) and by the writer (1924) that species of *Taphrina* could be grown in pure culture, Martin (1925) published notes on cultural behavior of several species. Examination of her cultures, made shortly afterwards, showed that three of them were wrongly named. One, called by Martin *Taphrina communis* has proved to be a species of *Torulopsis.* Her culture from *Quercus nigra,* called *Taphrina caerulescens,* is a species of *Rhodotorula,* and another isolate so named but from *Q. rubra* is a second and different species of *Rhodotorula.* Apparently the rest of Martin's cultures were authentic.

4. The writer's procedure in obtaining pure cultures is to place ascus-bearing leaf-fragments in the cover of an inverted petri dish of potato glucose (or other) agar. Ascospores are shot upward onto the agar, the spores of each ascus coming to lie together in a symmetrical group. If the process is not allowed to continue too long the groups of spores are spaced well apart and resultant colonies can be observed microscopically until it is convenient to transfer them.

(1946) considers that ascogenous cells and asci may be formed in culture, but was unable to find any binucleate cells.

In nature the ascospores bud readily, either within the ascus or after spore expulsion. There is reason to believe (Fitzpatrick, 1934, Mix, 1935) that propagation by budding in this "yeast stage" may continue indefinitely, the fungi surviving in this fashion on various plant surfaces and probably also in the soil. In other words species of *Taphrina* are yeasts (in the broad sense) during their asexual cycle. In fact if a species of *Taphrina* were brought into culture without knowledge of its previous parasitic existence, it would be called a species of *Torulopsis.*

In some cases, as in *Taphrina epiphylla,* infection apparently occurs soon after ascospore expulsion, but in other cases (presumably because host organs are susceptible only when young and tender), a period of oversummering and overwintering is undergone by the blastospores before infection. The occurrence of the "yeast stage" seems to be important in accomplishing survival during this prolonged period apart from the host tissues. For example, it is evident (Fitzpatrick, 1934, Mix, 1935) that *Taphrina deformans* can survive as a yeast for more than one year.

Infection by blastospores has been observed by Fitzpatrick (1934) and Mix (1935) in *Taphrina deformans.* Successful inoculation experiments were performed by Sadebeck (1882) with *Taphrina bullata* and *T. tosquinetii* and later (1888, 1890) with *T. epiphylla.* Fisch (1885) also reports successful inoculations with *T. tosquinetii* and *T. epiphylla.* Klebahn (1923), inoculating from pure culture, obtained infection with *Taphrina tosquinetii* on *Alnus glutinosa,* but failed in attempts with *T. epiphylla, T. sadebecki,* and *T. betulina* on their respective hosts. Wieben (1927) also used pure cultures in her inoculation-experiments, securing positive results with *Taphrina tosquinetii, T. epiphylla, T. deformans;* negative with *T. populina* (*T. aurea*), *T. bullata,* and *T. klebahni.*

Species of *Taphrina* are of three types as regards mycelial habit: intercellular forms (*Taphrina deformans,* etc.) developing abundant mycelium between the interior cells of leaf, stem, or fruit, and subsequently forming a subcuticular layer of ascogenous cells; subcuticular forms (*Taphrina epiphylla,* etc.) whose mycelium and ascogenous cells grow only beneath the cuticle; and wall-inhabiting forms (*Taphrina laurencia,* etc.), living entirely within the outer epidermal wall of the host. In *Taphrina maculans* (Butler,

1911) and *T. linearis* (Mix, 1939) this "wall-habit" is developed further. Flat bands of hyphae occur within radial walls between adjacent cells of the epidermis and of the underlying tissues. None of the intercellular or subcuticular forms is known to possess haustoria but specialized haustoria have been reported (Butler, 1911) for *T. maculans,* and unspecialized haustoria for *T. laurencia* (Giesenhagen, 1892), *T. osmundae* and *T. higginsii* (Mix, 1947). Most wall-inhabiting forms produce numerous ascogenous cells within a wall locule (Mix, 1939) but in the two species just named a single multinucleate hyphal segment occurs in each wall locule and this later gives rise to a single ascus (Mix, 1947).

Intercellular mycelium of species of *Taphrina* is for the most part developed within the spaces between host cells, but in passage of an infection hypha inward through the epidermis, and (later on) of mycelium outward to form a subcuticular layer, growth occurs perforce within radial walls between epidermal cells. In discussing *Taphrina deformans,* Martin (1940) states: ". . . vertical hyphae are found between radial walls of epidermal cells and not in these walls as described by Mix." This is a contradiction in terms. With no radially-placed intercellular spaces between epidermal cells of the peach only one location is possible for the vertically-growing mycelium and this may be described either as "in the cell wall" or "between cell walls." The writer's expression was chosen since it is not known whether the mycelium of *Taphrina deformans* dissolves out the middle lamella or whether it may not also attack the cellulose membranes.

Several species of *Taphrina* have been investigated cytologically. There is general agreement (Dangeard, 1895, Ikeno, 1901, Juel, 1921, Martin, 1924, Eftimiu, 1927, Martin, 1940) that mycelium with the host tissues is dicaryotic, each cell containing one or more pairs of nuclei which divide conjugately. Nuclear fusion occurs in ascogenous cells, as reported by Dangeard (1895) for *T. deformans* and by Juel (1921), Eftimiu (1927), and Martin (1924, 1940), for this and other species. The ascogenous cell is termed a chlamydospore by Juel.

In germination of the chlamydospore (ascogenous cell) two types of behavior have been observed. Juel (1921) found that in *Taphrina epiphylla* and in *T. sadebeckii* a pore forms in the outer wall of the chlamydospore, and the ascus emerges as a thin walled endospore through this widening pore.

In other species: *Taphrina betulina, T. carnea,* Juel found that the chlamydospore itself elongates to form the ascus; its wall becomes thinner in the process but does not rupture.

Martin (1940) writing of *Taphrina deformans* says: "After the nuclear fusion, the ascogenous cell elongates vertically and its thick wall is stretched to become the thinner wall characteristic of the ascus. The wall of the ascogenous cell does not break for the ascus to emerge as described by Pierce (1900) and Juel (1921)." Juel did not discuss *Taphrina deformans* in the paper referred to but Pierce (1900) writes as follows: "As already said, the walls of the ascogenous cells are heavy. The early steps in the development of the asci from these cells (the development of a papilla-like elevation on the upper surface of the cells) cause the rupture or the dissolution of the heavy wall where the elevation occurs. The phenomenon is that of the germination of a heavy-walled spore, or perhaps, more properly, the outgrowth or prolongation of an endospore through the rupture of the epispore."

Whether the ascus of *Taphrina deformans* ever forms in this manner seems to be difficult to determine. In all preparations made by the writer the ascogenous cell elongates to an ascus, in the fashion described by Martin (l. c.). If Pierce's observations are correct they cannot hold true for the majority of asci.

On the other hand, this phenomenon of ascus emergence by rupture of the chlamydospore wall (as described by Pierce for *Taphrina deformans,* and by Juel for *T. epiphylla*) is readily seen in certain other species. It has been observed (as noted below) in *Taphrina tosquinetii, T. sadebeckii, T. amentorum, T. epiphylla, T. occidentalis, T. thomasii, T. acerina* and *T. acericola.*

Meiosis occurs in the young ascus (Juel, 1921, Eftimiu, 1927, Martin, 1924, 1940). Eftimiu (1927) reports the diploid number for several species as four, while Martin (1940) reports it for *Taphrina deformans* as eight. Juel and Eftimiu find meiosis occurring in the first division of the fusion nucleus, Juel stating that in species possessing stalk cells the protoplasm migrates into the upper portion of the ascus before nuclear division, and that later an empty stalk cell is cut off. Martin (1924, 1940) reports that in *T. coryli* and *T. deformans,* the first division of the diploid ascus nucleus is mitotic and that the stalk cell possesses for a brief period a diploid nucleus and cytoplasm. These observations of Martin will, if confirmed, be extremely important, since the occurrence of a diploid

thallus is rare among fungi, having been previously reported by Guilliermond and others for certain yeasts (Guilliermond, 1940), and by Guilliermond (1928) for *Spermopthora gossypii.* A close relation between the Taphrinales and the Saccharomycetales would be indicated.

Ascospores are uninucleate and haploid, as are the blastospores derived from them. The dicaryotic condition seems to be attained in most species (Eftimiu, 1927, and others) by nuclear division, a dicaryon thus being a pair of sister nuclei.

In *Taphrina epiphylla* (*T. klebahni* is, as will appear later, a synonym) Wieben (1927) reported conjugation between sexually different ascospores (or blastospores) and development of a dicaryotic hypha from the fusion-cell. (Presumably this is the infection thread but the point has not been determined.) Wieben's observations were confirmed by the writer (1935).

Conjugation has not been observed as occurring regularly in any other species, though it seems to occur rarely in *Taphrina deformans* (Mix, 1935). With this fungus, however, infection has been obtained by Fitzpatrick (1934) and the writer (1935) using cultures derived from single ascospores.

TAXONOMIC ACCOUNT

I. SPECIES ON FERNS

Most species of *Taphrina* inhabiting ferns possess slender clavate asci. Giesenhagen (1895), calling this the "Filicina-type" of ascus, made it the basis for dividing the genus into subgenera. In other respects, especially in mycelial habit (Mix, 1939) species on ferns are remarkably diverse. That the series on ferns exhibits a variety of development not equalled by the species on any other host group, may be one indication of the antiquity [5] of the genus.

1. *Taphrina athyrii* Siemaszko

Taphrina athyrii Siemaszko, Bull. Musée du Caucase 12:20-28. 1919.

Causing small (5 mm. or less in diameter), yellow to brown, unthickened spots on leaves of *Athyrium filix-femina* Roth and *Dryopteris spinulosa* (Muell.) Kuntze. The spots are margined by small veins, though they often occupy more than one vein-islet. At maturity of the asci both surfaces of the spot are covered with a whitish bloom except for a narrow unwhitened margin.

Mycelium subcuticular.

Asci amphigenous, broadly clavate to nearly oblong, rounded or truncate at the apex, provided with a stalk cell. Ascospores round, ovate, elliptic, or fusiform, frequently budding in the ascus. (Figure 1, A, B.)

Dimensions: of asci, 13-17μ×5.5-10μ of *stalk cells,* 4.5-8μ× 5-8μ; of *spores,* 2.5-6μ × 2-3.5μ.

Distribution: On *Athyrium filix-femina,* Norway. On *Dryopteris spinulosa,* Caucasus.

Material examined: A. filix-femina. NORWAY: Sogn and Fjordane, Hauglund, Brekke in Lavik, Aug. 12, 1927, T. Lillefosse (received from Ivar Jørstad).

D. spinulosa. CAUCASUS: Pschu, Sept. 17, 1917. (Part of Siemaszko's type collection. Two lots of this were studied, one obtained from Dr. A. E. Jenkins, one from Siemaszko.)

This fungus was described by Siemaszko as occurring on *Athyrium filix-femina,* but in a letter accompanying a portion of his type

5. The occurrence of fossilized *Taphrina amentorum* in interglacial deposits near Ejstrup, Denmark, is reported by Lind (1913).

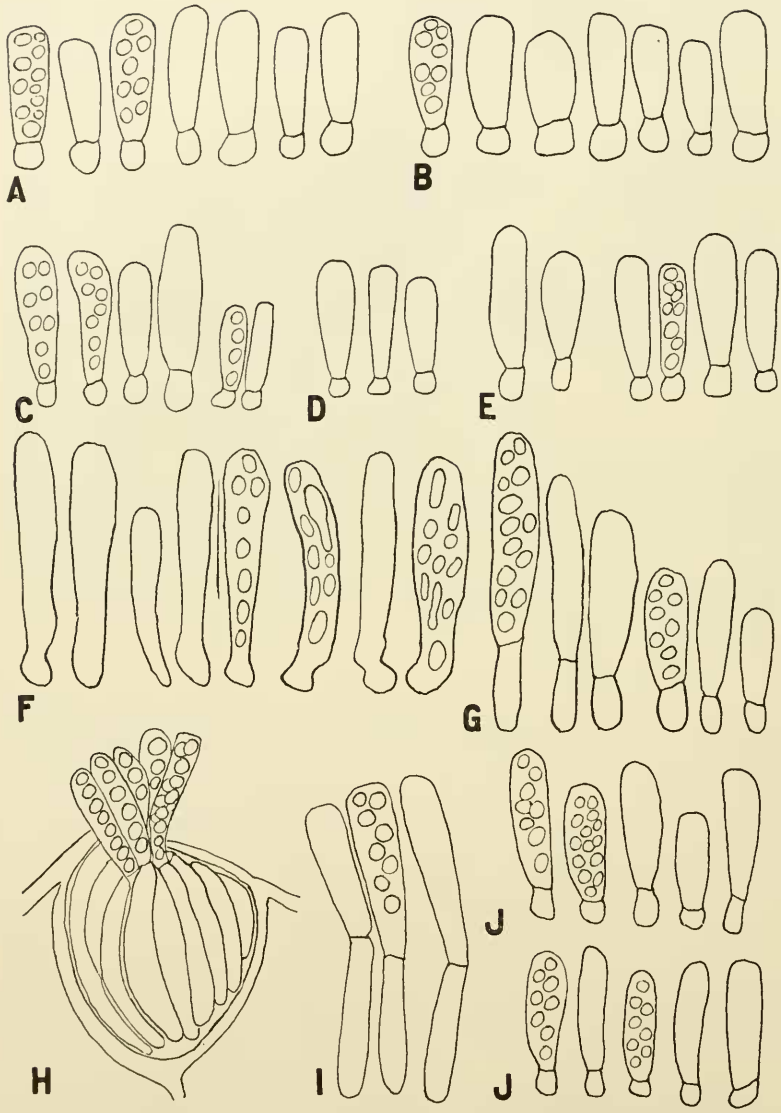

FIG. 1. Asci (×900) of, A, *Taphrina athyrii* on *Dryopteris spinulosa;* B, on *Athyrium filix-femina;* C, *T. hiratsukae* on *Onoclea sensibilis;* D, on *Pteretis nodulosa;* E, on *Pteretis struthiopteris;* F, *T. blechni;* G, *T. cystopteridis;* H, I, *T. californica;* J, *T. cornu-cervi.*

material he stated that he had been mistaken and that the host was *Dryopteris spinulosa*. The species name is saved from being a misnomer by the Norwegian material. *Taphrina athyrii* is very close to *T. hiratsukae* in all respects, but may be distinguished by the consistently broader ascus and by the nearly isodiametric stalk cell.

2. *Taphrina hiratsukae* Nishida

Taphrina hiratsukae Nishida, Miyabe Festschrift, Tokyo, 1911.
T. struthiopteridis Nishida, l. c.
T. struthiopteridis Siemaszko, Bull. Musée du Caucase, 12:20-28. 1919.
T. siemaszkoi (Siem.) Mix, Univ. Kansas Sci. Bull. 24:150-176. 1936.

Causing small (up to 5 mm. in diameter), yellow (becoming brown with age), unthickened spots on leaves of *Onoclea sensibilis* L., *Pteretis nodulosa* (Michx.) Nieuwl., *Pteretis struthiopteris* (L). Todaro, and *Thelypteris thelypteris* (L.) Nieuwl. The spots may be margined by the small veins of the leaf, though occupying more than one vein-islet. At maturity of the asci the lower surface of the spot becomes covered with a whitish bloom except for the narrow unwhitened margin.

Mycelium subcuticular.

Asci hypophyllous, clavate, rounded or truncate at the apex, provided with a stalk cell. Ascospores ovate or elliptic, frequently budding in the ascus. (Fig. 1, C, D, E.)

Dimensions: Of *asci*, 13-30μ × 4-18μ; of *stalk cells*, 4-10μ × 3-5μ; of *spores*, 2-6μ × 2-4μ.

Distribution: On *Onoclea sensibilis*, New York, Ontario, Pennsylvania, Japan. On *Pteretis nodulosa*, Manitoba, Wisconsin. On *Pteretis struthiopteris*, Caucasus. On *Thelypteris thelypteris*, Japan.

Material examined: Onoclea sensibilis. New York: Hudson Falls, Aug. 7, 1919, J. Dearness. Pennsylvania: Houserville, Aug. 10, 1921, C. R. Orton and W. A. McCubbin. Ontario: swamp east of Wilcox Lake, Aug. 4, 1930, H. S. Jackson. Japan: Pref. Iwate, Morioka, July 22, 1934, K. Togashi.

Pteretis nodulosa. Wisconsin: Weyerhaeuser, J. J. Davis.

Pteretis struthiopteris. Caucasus: Pschu, Sept. 13, 1917, W. Siemaszko (duplicate of Siemaszko's type material of *T. struthiopteridis*).

Thelypteris thelypteris. Japan: Pref. Iwate, Mt. Iwate, Aug. 17, 1903, G. Yamada.

In the species list previously published (Mix, 1936a), *Taphrina struthiopteridis* Siemaszko was, on the basis of Siemaszko's descrip-

tion, held to be distinct from *T. struthiopteridis* Nishida, and the fungus was therefore renamed *Taphrina siemaszkoi.* Siemaszko described this fungus as having asci 28-40μ × 6-7μ and did not mention a stalk cell, while Nishida's fungus was described as having asci 16-28μ × 4-6μ with stalk cells 4-7μ × 3-4μ. In a letter accompanying his type material Siemaszko stated that his measurements had been wrong, giving the following as correct: Asci 17.5-32μ × 6-7.5μ, again not mentioning the stalk cell. He said further that his fungus was probably identical with *T. struthiopteridis* Nishida. Study of the material obtained from Siemaszko, and of duplicate material in the Farlow Herbarium showed asci 17-28μ × 5-7μ, and stalk cells 4-7μ × 3-6μ.

It is not possible to distinguish from each other the fungi under discussion either on the basis of host lesions or of size and shape of asci and stalk cells. They are therefore held to be the same species.

Since Nishida described his two fungi in the same paper it becomes a question which name should receive priority. The name *Taphrina hiratsukae* Nishida is chosen since it would precede *T. struthiopteridis* in an alphabetical list of species. The close similarity of *Taphrina hiratsukae* to *T. athyrii* has been mentioned above. It is not impossible that these two species are identical.

3. *Taphrina blechni* (Bresadola) ex Mix.

Taphrina blechni Bresadola ex Mix, Trans. Kansas Acad. Sci. **50**:77-83. 1947.

Causing small, round or ellipsoid, unthickened spots on leaves of *Blechnum* sp.

Mycelium subcuticular.

Asci amphigenous, clavate, truncate at the apex, often with a curved foot, lacking a stalk cell. Ascospores ellipsoidal. Numerous elongate spores (apparently blastospores) may be present in the ascus. (Fig. 1, F.)

Dimensions: Of *asci,* 23-60μ × 4-7μ; of *ascospores,* 2-5μ × 2-4μ; of *blastospores,* 5-6.5μ × 0.5-1.5μ.

Distribution: Brazil.

Material examined: BRAZIL: Rio de Janeiro, Serra Geral, Oct. 1891, E. Ule (E. Ule, Herb. Brasil. 1786). Bot. Mus. Berlin, Bot. Mus. Stockholm.

Bresadola named (in the above mentioned Exsiccati) this fungus but did not publish a description. This has been supplied by the writer (Mix, 1947a).

4. *Taphrina cystopteridis* Mix

Taphrina cystopteridis Mix, Mycologia **30**:563-569. 1938.

Causing small (0.5 to 2.0 mm. in diameter) galls on leaves of *Cystopteris fragilis* (L.) Bernh.

Mycelium intercellular.

Asci epiphyllous or amphigenous, clavate, rounded or truncate at apex, provided with a stalk cell. Ascospores eight, round, ovate or elliptic.

Dimensions: Of *asci*, 20-30μ × 4-7.5μ, of *stalk cells*, 6-19μ × 4-6μ, of *spores*, 3-6 × 2-3.5μ. (Fig. 1, G.)

Distribution: Indiana, Kansas, Wisconsin.

Material examined: INDIANA: Daviess County, Glendale, June 4, 1923, C. C. Deam; Greencastle, May 23, 1922, id. KANSAS: Neodesha, June, 1936, W. H. Horr (type material); same locality, June, 1937, and June, 1938, A. J. M. WISCONSIN: Brodhead, Sept. 16, 1926, J. J. Davis.

The earliest collection of this fungus is the one made at Greencastle, Indiana, by Deam, and the earliest mention is by Davis (1929) who identified the fungus collected at Brodhead, Wis., as *Taphrina filicina* Rostr.

5. *Taphrina californica Mix*

Taphrina californica Mix, Mycologia **30**:563-569. 1938.

Causing small to large (several centimeters in extent when swollen) orange-brown galls on leaflets, midribs, and petioles of *Dryopteris arguta* (Kaulf.) Wats. The galls are fleshy and gelatinous, becoming small, wrinkled, and hard when dry; much swollen when wet. The gall originates from the epidermis and the mycelium develops entirely within the outer walls of the surface cells ("epidermal cells") of the gall. Ascogenous cells develop in a much enlarged wall locule, and the mature asci burst forth and protrude from this locule.

Asci clavate, truncate or rounded at the apex, provided with stalk cells; ascospores usually eight, ovate to elliptic. (Fig. 1, H, I.)

Dimensions: Of *asci*, 23-46μ × 7-8μ; of *stalk cells*, 17-30μ × 5-7μ; of *spores*, 4-5μ × 2-3μ.

Distribution: California, Mexico, Oregon.

Material examined: CALIFORNIA: Lake Phenix, Marin County, Aug. 21, 1930, Victor Duran; same locality, Sept. 4, 1930, H. E. Parks (California Fungi 343); Lee Bonar, Nov. 28, 1937 (type); Carmel, Big Sur River, June 23, 1938, C. E. Scott; Palo Alto, San

Francisquito Creek, Sept. 25, 1938, R. H. Thompson; San Mateo County, Los Altos, May 30, 1939, R. H. Thompson.

The collection by Parks was widely distributed (as California Fungi 343) under the name *Taphrina filicina* Rostr. Many subdivisions of this collection in various herbaria have been examined, but in all of them the fungus is immature, showing ascogenous cells but no asci. The galls are characteristic.

Taphrina californica is apparently common in the coastal region from lower California to central Oregon. Dr. R. H. Thompson kindly searched the collection of ferns in the Stanford University Herbarium, looking for those with unmistakable galls of *T. californica.* Ferns bearing galls were found to have been collected from the following localities: CALIFORNIA: Amador County, Cedar Creek; Marin County, Petaluma; Monterey County, above P. I. Co. Dam; Rand County, City Creek; San Diego County, East Illinois River, four miles from Takilma, seven miles above Lakeside; San Mateo County, Santa Cruz Mountains, King's Mountain; Santa Clara County, Los Gatos; Tulare County, Sequoia National Park. OREGON: Multnomah County, Elk Rock. MEXICO: Santo Tomas (Baja California).

6. *Taphrina cornu-cervi* Giesenhagen

Taphrina cornu-cervi Giesenhagen, Flora **76**:130-156. 1892.

Causing long, branched, antler-like outgrowths on leaves of *Polystichum aristatum* (Forst.) Presl.

Mycelium intercellular.

Asci covering surface of outgrowth, clavate, rounded at apex, provided with a stalk cell; ascospores eight, round, ovate or elliptic, often budding in the ascus.

Dimensions: Of *asci,* 18-24μ × 6-10μ; of *stalk cells,* 5-8μ × 5-7μ; of *spores,* 3.5-4.5μ × 2-3μ. (Giesenhagen reported asci 24μ × 5-6μ, stalk cells 4-6μ × 2-4μ, spores not present.) (Fig. 1, J.)

Distribution: Ceylon, Fiji Islands, India, Japan, Nepal, New Caledonia, Tahiti.

Material examined: FIJI: Nodarivatu, Viti Levu, May-July, 1927, H. E. Parks (Plants of V. L. F. Coll. by Bernice P. Bishop Museum and Univ. Calif.) INDIA: Nilgiri, no date, ex Herb. Sydow (in Bot. Mus. Stockholm); Coonoor, Sim's Park, Nilgiri Hills, no date (received 1939), M. O. P. Iyengar. JAPAN: Hamemura, Prov. Tosa, 1908 (ex Herb. Morioka Imp. Coll. Agric. and For.).

In addition to the preceding the following three specimens have been examined superficially. They bear no dates. They are in the Patouillard Herbarium, now owned by the Farlow Herbarium. One is labelled: "Herbarium Stendel, Pl. Indiae Or. (M. Nilgiri) Ed. R. F. Hohenacher, 901. *Roestelia tubaeformis* Rabenh, n. sp., In *Aspidio cervifolio* Kze. In montibus Nilgiri." The second: "*Taphrina tubiforme* Lagerh., Nouvelle Caledonie." The third: "*Taphrina tubiforme* Lagerh., Tahiti. Herb. Pancher." In these specimens the outgrowths are characteristic.

Giesenhagen (1892) described the fungus from material collected in Nepal and Ceylon. Sadebeck (1895) reports specimens from Queensland, Fiji, and Samoan Islands.

7. *Taphrina vestergrenii* Giesenhagen

Taphrina vestergrenii Giesenhagen, Bot. Zeit. **59**:115-142. 1901.
Exoascus vestergrenii (Gies.) Saccardo and Sydow, Sylloge Fungorum **16**:1152.

Causing small (up to 5 mm. diameter), fleshy, brownish (probably lighter colored in fresh material) galls on leaves of *Dryopteris filix-mas* Schott, and perhaps also on *D. lacera* O. Kuntze.

Mycelium subcuticular.

Asci hypophyllous or amphigenous, clavate, rounded or truncate at the apex, stalk cell pointed or truncate below.

Dimensions: Of *asci,* 23-50μ × 6-10μ; of *stalk cells,* 10-23μ × 4-10μ; of *spores,* 3.5-6μ × 2.5-4μ. Ascospores eight, round, ovate or elliptic, often budding in the ascus. The asci are closely packed and in some specimens both asci and stalk cells show an irregular contour. (Fig. 2, A.)

Distribution: Northern and Central Europe (Japan and China?).

Material examined: Denmark: Skjelskör, June 23, 1907, J. Lind. Germany: Allgau, Einödsbach, Feldhorn, July, 1909, W. Krieger; Alsace, Hohneck, Fischboedle, July 14, 1910, H. Sydow (Sydow Myc. Germ. 978); Baden, Feldhorn, Aug., 1903, G. Lagerheim. Russia: Abro Island, near Osel, July 1, 1899, T. Vestergren (Rehm. Ascomyceten, 1412, dupl. of type). Sweden: Uppland, Kuggvik, Lilla Möja, July 4, 1923, T. Vestergren.

The asci were described by Giesenhagen as 25μ × 6μ, and dimensions of the stalk cell were not given. Jankowska (1928) gave dimensions of asci as 24-35μ × 5-7μ, of stalk cells as 12-21μ × 4-6μ, and stated that stalk cells may be pointed. Spore-dimensions as given by Giesenhagen and Jankowska are 7μ×2.5-3μ.

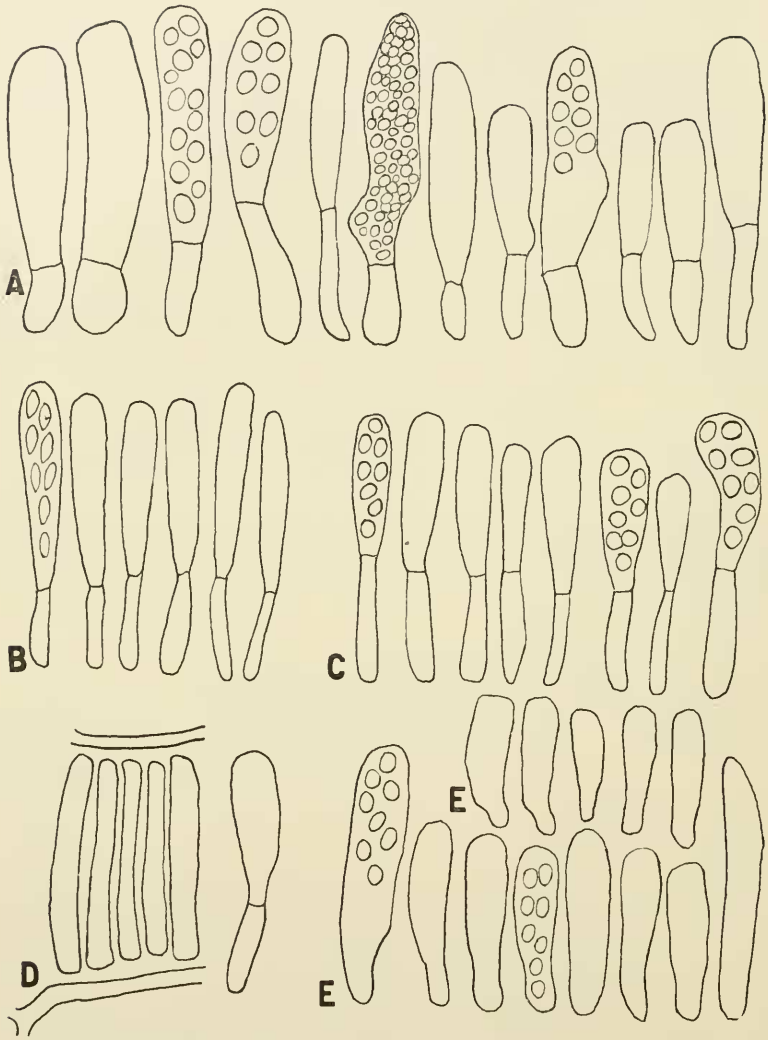

FIG. 2. Asci (× 900) of A, *Taphrina vestergrenii;* B, *T. gracilis;* C, *T. fusca;* D, *T. fusca* (Bubák's "*T. moriformis*"), ascogenous cells and one ascus; E, *T. filicina.*

Besides these specimens of the undoubted *T. vestergrenii* three specimens from the Herbarium of the Morioka Imperial College of Agriculture and Forestry have been studied, all labelled "*Taphrina vestergrenii* Giesenhagen on *Dryopteris lacera* O. Kuntze": JAPAN: Prov. Ise, Mt. Komono, Aug. 1903, K. Nakanshiki; Prov.

Kochi, Mt. Yanaze, Oct. 1904, T. Yoshinaga; Prov. Tosa, Higishikawamura, Aug. 1905, T. Yoshinaga. The galls in these specimens are overmature, and no asci can be found. The galls show greatly distorted vascular bundles, a feature not observed in the European specimens.

A specimen of a fungus on an unidentified species of *Dryopteris* collected at Mt. Omei, Szechwan, China, Aug. 3, 1928, by W. P. Fang may be *Taphrina vestergrenii*. The fungus is immature, showing only subcuticular mycelium, but the gall resembles that on *Dryopteris lacera*. The specimen in question was kindly donated by Dr. D. H. Linder, and a duplicate remains in the Farlow Herbarium.

8. *Taphrina gracilis* Mix

Taphrina gracilis Mix, Mycologia **30**:5:563-579. 1938.

Causing small (up to 5 mm. diam.) thickened areas, resembling small lesions of peach leaf curl, on leaves of *Dryopteris marginalis*, (L.) A. Gray.

Mycelium intercellular.

Asci epiphyllous or amphigenous, clavate, rounded at the apex, provided with a stalk cell; ascospores eight, fusiform.

Dimensions: Of *asci*, 26-36μ × 4-6μ; of *stalk cells*, 13-23μ × 3-4μ; of *spores*, 5-8μ × 2-2.5μ. (Fig. 2, B.)

Distribution: Labrador Lake, New York.

Material examined: Cornell Univ. Dept. Plant Path., New York Bot. Gard., Brooklyn Bot. Gard., Fungi collected near Ithaca, N. Y., June 2-7, 1919, No. 1256, Labrador Lake, Coll. E. W. Olive, A. H. W. Povah, L. R. Hesler, F. J. Seaver, H. H. Whetzel, H. M. Fitzpatrick, et al. In New York Bot. Gard. Herb. (Type). Duplicate material at the other institutions named does not show the fungus in mature condition.

Because this fungus is known only from a single meager collection the writer (l. c.) had some hesitation in describing it as a distinct species. The temptation was to consider it as a host-variant of *Taphrina fusca* (known to occur in the same locality) or of *T. vestergrenii* (not known in North America). However, the characteristic slender asci and the fusiform spores differentiate it from both these species. Moreover the gall is different from those formed by *T. fusca* and *T. vestergrenii* (q. v.), being characterized by moderate hypertrophy of all the cells of the lamina.

9. *Taphrina fusca* Giesenhagen

Taphrina fusca Giesenhagen, Flora **86**:100-109. 1899.
Exoascus fuscus (Gies.) Saccardo and Sydow, Sylloge Fungorum **16**:803.
Taphrina moriformis Bubák, Bull. Herb. Boissier, Ser. 2, **6**:393-488. 1906.

Causing small (up to 5 mm. in diam.) fleshy (convoluted when dry), yellowish galls on leaves of *Dryopteris rigida* (Hoffm.) Underw., *D. rigida* var. *australis* Christ., *D. spinulosa* (Muell.) Kuntze, *D. spinulosa* var. *americana* (Fisch.) Fern., and var. *intermedia* Underw. According to Giesenhagen (l. c.) the gall, though exhibiting considerable hypertrophy, is epidermal in origin, and this seems to be the case in the various specimens examined. Fresh material, with galls of various ages, would be necessary in order to determine this point with exactness.

Mycelium subcuticular.

Asci epiphyllous, or sometimes amphigenous, clavate, rounded or truncate at the apex, provided with a stalk cell which may equal or exceed in length the ascus proper. Ascospores globose to elliptic, sometimes budding in the ascus. (Fig. 2, C, D.)

Dimensions: Of *asci*, 19-27μ × 4-8μ; of *stalk cells*, 15-34μ × 4-7μ; of *spores*, 3.5-7μ × 2-3.5μ.

Distribution: On *Dryopteris rigida*, Albania. On *D. rigida* var. *australis*, Sicily. On *D. spinulosa* et var., eastern North America.

Material examined: Dryopteris rigida. ALBANIA: Njegusi prope Cetinje, July, 1903, F. Bubák (Bubák's type specimen of *Taphrina moriformis*, obtained on loan from Brooklyn Bot. Gard.). *D. rigida* var. *australis.* SICILY: Near Palermo, Nov. 1898, K. Giesenhagen (Giesenhagen's type specimen of *T. fusca*, obtained on loan from Univ. of Munich Herbarium). *D. spinulosa* et var. NEW BRUNSWICK: Campobello, July, 1902, W. G. Farlow (Rel. Farl. 149). NEW HAMPSHIRE: Mt. Lafayette, July 20, 1935, D. H. Linder; Mt. Washington, Tuckerman Ravine Trail, July 6, 1931, K. S. Chester and J. H. Faull (Herb. J. H. F. 9934). VERMONT: Mt. Mansfield, July 15, 1932, J. H. Faull and K. S. Chester (Herb. J. H. F. 10734). WEST VIRGINIA: Bayard July, 1891, W. C. Sturgis.

Bubák's description of *Taphrina moriformis* gives dimensions of asci as 30-45μ × 4-6μ, stalk cells not mentioned, spores not seen. The asci are further described as narrow at the apex. Examination of his type material makes it appear that he saw and described no asci but only ascogenous cells. These are long and narrow, 30-46μ × 5μ, and form a close layer beneath the epidermis (Fig. 2, D). Diligent search of the material revealed a single mature ascus with a

stalk cell and spores. Dimensions of this ascus were 33 × 10μ, of the stalk cell, 17 × 5μ, and of the spores, 4.5 × 5μ. The gall itself is somewhat larger than in other collections of *Taphrina fusca*. Judging from its dried state it may reach one centimeter in diameter when fresh, and is much convoluted. That this convolution is apparent in the fresh state may be inferred from Bubák's description and from his choice of a specific name. There is no doubt that Bubák's and Giesenhagen's fungi, occurring on the same host species, are identical.

The writer's reasons for assigning the American fungus on *Dryopteris spinulosa* to *Taphrina fusca* have been given earlier (Mix, 1938).

The yellowish or brownish coloration of the galls is found in the walls of the outer cells ("epidermal cells"), all fungous structures being hyaline.

10. *Taphrina filicina* Rostrup ex Johanson

Taphrina filicina Rostrup ex Johanson, Bih. Kongl. Vetensk. Akad. Handl. **13**:3-28. 1887.
Ascomyces filicinus Rostrup, Vestergren, Micr. Rar. Sel. No. 813.
Exoascus filicinus (Rostr.) Saccardo, Sylloge Fungorum **8**:819.

Causing thickened areas of the leaf-curl type or small fleshy galls on leaves of *Dryopteris spinulosa* (Muell.) Kuntze, *D. spinulosa* var. *americana* (Fisch.) Fern., and var. *intermedia* Underw. As pointed out by Giesenhagen (1899) the gall is not epidermal in origin, but all leaf tissues are involved.

Mycelium intercellular.

Asci amphigenous, clavate, rounded at the apex, attenuate at the base, lacking a stalk cell. Ascospores ovate to elliptic. (Fig. 2, E.)

Dimensions: Of *asci*, 18-46μ × 6-10μ; of *spores*, 3.5-6.5μ × 2-3.5μ.

Distribution: northern Europe and eastern North America.

Material examined: Germany: Tirol, Sondestal, Geschnitztal, Aug., 1939, F. Wettstein. Russia: Prov. Novgorod, Beresaida, July, 1890, W. Tranzschel (Jaczewski, Komarov, Tranzschel. Fungi Rossiae Exsiccati, 27). Sweden: Dalarna, Avesta, Elfnäshage, July, 1879, Conrad Indebetou (duplicate material from the type-collection, Bot. Mus. Stockholm.) Poland: Kraków, no date, Raciborski (Ex Herb. A. Wróblewski). New York: Ithaca, Enfield Gorge, July 14, 1917, J. H. Faull (Herb. J. H. F., 1804); *ibid*, July 14, 1917, L. B. Walker; Coy Glen, July 3, 1927, L. B. Walker; McLean, McLean Preserve, July 25, 1937, W. W. Ray (Herb. W. W. R. 371). Pennsylvania: Mt. Jewett, McKean Forest, July 7, 1938, A. E. Edgecombe and L. O. Overholts (Ex. Herb. L. O. O.).

The wide range of variation in ascus size between European and American specimens of this fungus has already been pointed out (Mix, 1938). Many specimens of other species of *Taphrina* in American herbaria are wrongly labelled *T. filicina,* American collectors having referred fern-inhabiting species of *Taphrina* to this species indiscriminately. Such specimens have been properly allocated in the present account without, however, mention in every case of the mistaken identification.

Jaczewski (1926) mentions Russian specimens of *Taphrina filicina* on "*Nephrodium, Phegopteris,* and *Athyrium filix-femina.*" It has not been possible to obtain these specimens for study.

11. *Taphrina thaxteri* Mix

Taphrina thaxteri Mix, Mycologia **31**:4:445-454. 1939.

Causing pale yellowish unthickened spots, one centimeter or more in extent, on leaves of *Dryopteris poiteana* (Bory) Urban.

Mycelium growing within the epidermal wall.

Asci hypophyllous, protruding from a wall locule, clavate, rounded at the apex, provided with a stalk cell; ascospores eight, often fusiform. (Fig. 3, A, B, C.)

Dimensions: Of *asci,* 20-27μ × 5-7μ; of *stalk cells,* 7-15μ × 5-7μ; of *spores,* 3.5-5μ × 2-3μ.

Distribution: Trinidad.

Material examined: TRINIDAD: Arima: Verdant Vale, no date, R. Thaxter (Herb. Roland Thaxter, "Bequest 1932").

12. *Taphrina fasciculata* (Lagerh. and Sadeb.) Giesenhagen

Taphrina fasciculata (Lagerh. and Sadeb.) Giesenhagen, Flora **81**:267-361. 1895.
Magnusiella fasciculata Lagerheim and Sadebeck, Ber. Deutsch. Bot. Ges. **13**:265-280. 1895.

Causing small unthickened spots with a grayish or whitish ascus-bearing center, and a narrow pale yellowish margin (thus resembling spots caused by *T. lutescens*) on leaves of *Dryopteris* sp. (*D. filix-mas*?).

Mycelium intercellular.

Asci short-clavate and provided with a short stalk cell, or long-clavate with a long stalk cell, or arising from a two-celled or three-celled hypha. The longer asci with longer stalk cells are frequently empty, having discharged their spores. The basal cell of a two-celled or three-celled stalk often has a bent foot. Ascospores eight, ovate to elliptic. (Fig. 3, D.)

Dimensions: Of *asci,* 20-53μ × 8-10μ; of *stalk cells,* 10-66μ ×

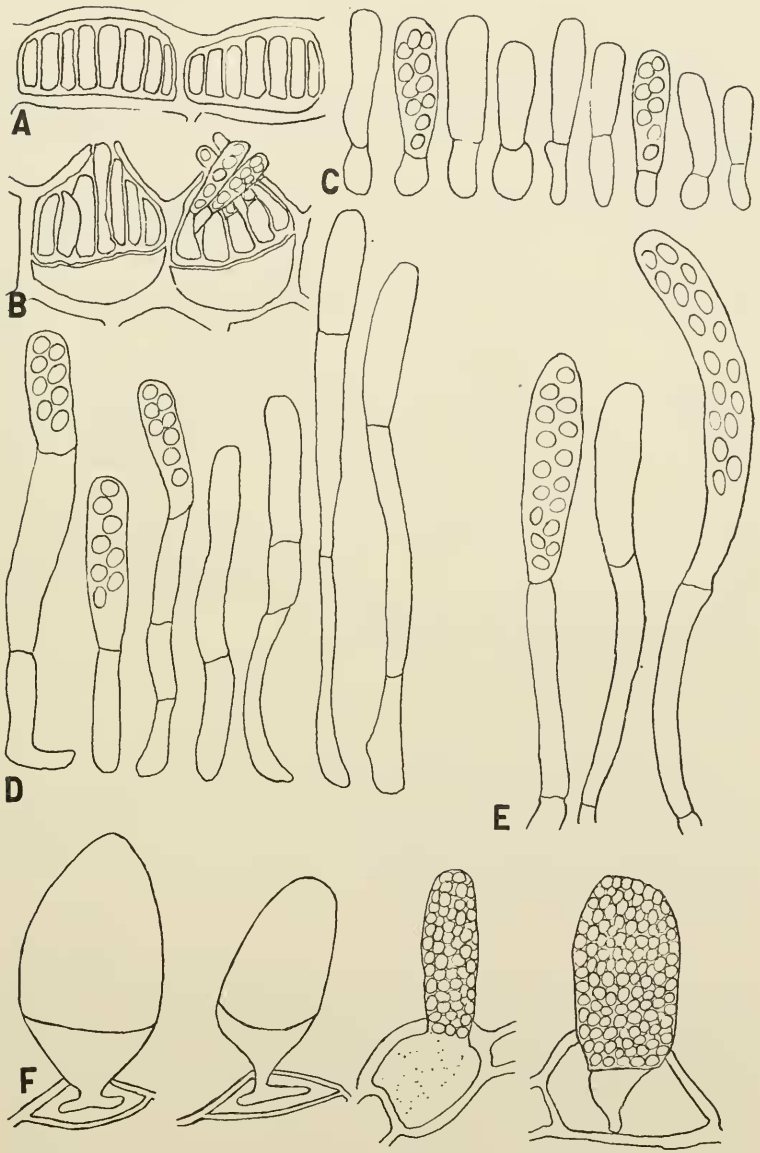

FIG. 3. A, B, C, *Taphrina thaxteri;* A, Ascogenous cells in wall locule; B, Asci emerging from locule; C, Asci. D, Asci of *T. fasciculata;* E, of *T. ecuadorensis;* F, of *T. osmundae.* All × 900.

7-8μ; of second or third cells of septate *stalk,* ca. 40μ × 7μ; of *spores,* 5-7μ × 2.4-4μ.

Distribution: Ecuador.

Material examined: ECUADOR: Quito, Rio Machángara, no date, Lagerheim, det. Sadebeck (Herb. Reg. Monac.). Type specimen. Munich Museum.

The inner packet containing this material bears the following, presumably by Sadebeck: "*Magnusiella Nephrodii* Lagerh. in herb., bildet kleine weissliche oder graüliche nicht blasige flecken auf *Nephrodium (filix-mas).* Trotz vielem suchen nur an einen standort und nur an einem wedel beobachtet. Der standort war sehr feucht und schattig. Rio Machángara bei Quito, Leg. G. v. Lagerheim. Am nächsten mit *M. lutescens* verwandt, hat jedoch lang keulige asken mit eiformigen sporen (keine conidien), ähnelt daher M. potentillae." In another handwriting is added: "*Magnusiella fasciculata* v. Lagerheim and Sadebeck."

Sadebeck gives dimensions of the asci as 50-70μ × 9-12μ, and states that a stalk cell is present which is narrower than the ascus. These dimensions are hard to understand unless Sadebeck included stalk cell and ascus in his measuring.

It is impossible to determine the host species from the material available.

13. *Taphrina ecuadorensis* Sydow

Taphrina ecuadorensis Sydow, Ann. Myc. 37:275-438. 1939.

Causing small (1.5 to 3 mm. diam.) yellowish to yellow brown (with whitish central area bearing asci and narrow margin) unthickened or only slightly thickened spots on leaves of *Dryopteris cheilanthoides* (Kze.) C. Chr.

Mycelium intercellular, abundant (stated to be subcuticular by Sydow).

Asci cylindric, clavate, rounded at apex, borne on the ends of septate hyphae, which often arise from a rather dense weft of mycelium (in this habit resembling *Taphrina potentillae*). The asci form dense tufts, pushing up through the epidermis and rupturing it. Ascospores eight, elliptic to fusiform. (Fig. 3, E.)

Dimensions: Of *asci,* 23-40μ × 6-10μ; of *mycelial cell* next to ascus (corresponding to stalk cell), 23-56μ × 4-7μ; of *spores,* 4-6.5μ × 2-2.5μ.

Distribution: Ecuador.

Material examined: ECUADOR: Tungurahua: Hacienda San An-

tonio pr. Baños, Dec. 31, 1937, H. Sydow (Fungi Aequatoriensis 651). Part of type, obtained from Sydow.

Sydow wrote that he found the fungus "somewhat difficult to study," which is indeed the case. He does not report the intercellular mycelium nor the rupturing of the host epidermis by the compact tufts of asci, though he describes the asci as crowded ("dense conferti"). Neither does he mention that the asci arise from the ends of septate hyphae, but describes a stalk cell ("in matricem non penetrante"), 20-35μ × 4-6μ.

This species is probably synonymous with the preceding but sufficient material is not at hand to demonstrate it.

14. *Taphrina osmundae* Nishida

Taphrina osmundae Nishida, Miyabe Festschrift, Tokyo, **1911**:157-212.

Causing small to large, yellowish to light brown, unthickened spots (sometimes involving the whole leaflet), on leaves of *Osmunda regalis* (L.) var. *japonica* Willd. A sparse white powdery layer of asci covers the lower surface of the spot and less commonly smaller areas occur on the upper surface.

Mycelium developing within outer walls of epidermal cells, forming wall locules, each of which contains a single ascogenous cell.

Asci hypophyllous, less commonly also epiphyllous, scattered, one ascus formed in each wall locule, emerging as a small papilla which gradually enlarges to an oblong ascus, a small, triangular stalk cell remaining inserted in the locule. Ascospores not seen, blastospores numerous, often forming in the ascogenous cell (young ascus) before ascus emergence; in mature asci the blastospores occur in a peripheral layer close to the wall. (Fig. 3, F.)

Dimensions: Of *asci,* 26-63μ × 17-27μ; of *stalk cells,* 6-17μ × 8-17μ; of *spores* (blastospores), 3-4μ × 2-3.5μ.

Distribution: Japan.

Material examined: Japan: Pref. Tottori, Taisenji, July 1, 1924, K. Togashi (Herb. Morioka Imp. Coll. Agric. and For. 193); Pref. Iwate, Mt. Iwate, June 13, 1934, K. Togashi (Herb. Morioka Imp. Coll. Agric. and For.); Kyûsû, Mt. Kirisama, May 29, 1938, I. Hino (Herb. Lab. Path. Veg. Miyazaki Kôtô Norni-Gûkko).

In early stages a network of small-celled hyphae forms within the epidermal wall, and haustoria are sent into the cell cavity beneath. Ultimately each wall locule contains a single multinucleate hyphal body, with a thin membrane. From this ascogenous cell a single ascus arises as explained above. The intermediate development is not clear, and it has not been possible to trace the

nuclear history from the rather scanty herbarium material at hand. Cytological study of this fungus would be very desirable, since, if the interpretations here given are correct, it is a highly aberrant species, showing some resemblance to members of the genus *Taphridium* Lagerh. and Juel.

Although Nishida's paper is in Japanese, it may be assumed from his English summary and from his figure that he missed the features described above ("wall habit" of mycelium, emergence of asci, presence of a pedicellate stalk cell).

15. *Taphrina higginsii* Mix

Taphrina higginsii Mix, Mycologia **39**:71-76. 1947.

Causing small (up to 5 mm. diam.) yellowish unthickened spots on leaves of *Osmunda cinnamomea* L.

Mycelium developing within outer epidermal wall, occasionally forming unspecialized haustoria which project into the cell cavity. A multinucleate hyphal element (ascogenous cell) forms in each wall locule, from which a single ascus emerges. Ascospores not seen. Numerous spores (blastospores) appear in a peripheral layer in the ascus before, during, or after emergence.

Asci hypophyllous or amphigenous, oblong-cyclindric, rounded at apex, with a narrower cyclindric stalk cell, the lower part of which is expanded into a foot within the wall locule. (Fig. 4, A.)

Dimensions: Of *asci*, 40-80μ × 13-23μ; of *stalk cells*, 10-17μ × 8-10μ; of *spores*, 2-5μ × 1.5-4μ.

Distribution: Georgia.

Material examined: GEORGIA: Hamilton, Pine Mountain, Blue Springs Farm, May 26, 1938, B. B. Higgins.

This fungus, for which the writer is indebted to B. B. Higgins, differs from *Taphrina osmundae* by its larger asci, and its narrow, nearly cyclindric stalk cell. It also causes smaller spots, as is natural on the more finely dissected fronds of the host. Like *T. osmundae* it would repay cytological study.

An earlier collection made by W. A. Murrill at Blacksburg, Va., in 1897 could not be positively identified as *T. higginsii*. An account of this has been previously given (Mix, 1947).

16. *Taphrina polystichi* Mix

Taphrina polystichi Mix, Mycologia **30**:563-579. 1938.

Causing small to large (up to 1 cm. diam.) yellowish or yellow-brown thickened spots on leaves of *Polystichum acrostichoides* (Michx.) Schott.

Mycelium intercellular.

Asci epiphyllous, occasionally also hypophyllous, crowded, clavate, rounded at apex, provided with a stalk cell, ascospores usually eight, ovate to elliptic, sometimes budding in the ascus. (Fig. 4, C.)

Dimensions: Of *asci,* 23-53μ × 4.5-8.5μ; of *stalk cells,* 13-23μ × 4-7μ; of *spores,* 3-6μ × 2-4μ.

Distribution: eastern North America.

Material examined: New York: McLean, McLean Bog, July 5, 1940, A. J. M.; Oneida, June 10, 1935, H. D. House; Ringwood, July 23, 1940, A. J. M. North Carolina: Durham, 1935, F. A. Wolf; Nantahala Gorge, May 29, 1941, A. J. M. Ohio: Hamilton Co., 1934, Wm. Bridge Cooke. Pennsylvania: Lycoming Co., Trout Run, June 6, 1925, L. O. Overholts and L. T. Deniston (Herb. L. O. O. 9839). Tennessee: Cades Cove, May 30, 1937, L. R. Hesler. West Virginia: Bayard, July, 1891, W. C. Sturgis.

This is the most frequently collected and apparently the most common and widely distributed fern-inhabiting species of *Taphrina* in North America. It occurs throughout the eastern United States and adjacent Canada. The first collection is that made by Sturgis in West Virginia in 1891, and the first mention in literature is that by Coker (1910) who called the fungus *Exoascus filicinus.*

17. *Taphrina wettsteiniana* Herzfeld

Taphrina wettsteiniana Herzfeld, Oesterreich Bot. Zeitschr. **60**:249-254. 1910.

Causing small (up to 8 mm. diam.) roundish, well-defined, lemon-yellow (brown in age) slightly thickened spots on under surfaces of leaves of *Polystichum lonchitis* (L.) Roth. Spots scarcely visible on the upper surface or only as a paler area.

Mycelium intercellular.

Asci hypophyllous or amphigenous, clavate, rounded at apex, with or without a stalk cell; ascospores eight, fusiform or slightly curved, usually with two globules. (Fig. 4, B.)

Dimensions: Of stalkless *asci,* 32-53μ × 6-10μ; of stalked *asci,* 25-38μ × 6-10μ; (17-23μ × 5-7μ according to Herzfeld); of *stalk cells,* 6-13μ × 5-8μ; of *ascospores,* 4.5-6.5μ × 2-4μ. (Blastospores may be elongate and bacterioid, 5 × 1μ.)

Distribution: Tyrol.

Material examined: Tyrol: Sondestal ("sistendal des Geschniztel, loc. class.") Aug., 1939, Fr. Wettstein.

Herzfeld, who described the fungus while working at Munich under the direction of R. Wettstein, apparently designated no type

specimen. On inquiry at the Munich Museum it was learned that preserved material of Herzfeld's collection was known to have been in the museum but in 1938 it could not be found. However in 1939, Dr. Fr. Wettstein kindly obtained fresh material from the place of original collection and sent it to the writer. This material, deposited in the Mycological Herbarium, University of Kansas, is chosen as the lectotype.

Although the mycelium is intercellular, very little modification of the mesophyll occurs. The epidermis is browned.

18. *Taphrina faulliana* Mix

Taphrina faulliana Mix, Mycologia **30**:563-579. 1938.

Causing small (up to 5 mm. diam.) round to oval, lemon-yellow (brown in age or on drying) slightly thickened spots on leaves of *Polystichum munitum* (Kaulf.) Presl.

Mycelium subcuticular.

Asci hypophyllous, sometimes also epiphyllous, closely packed, long-clavate, provided with a stalk cell. Ascospores not yet observed, blastospores numerous, long-elliptic to bacilliform. (Fig. 4, D.)

Dimensions: Of *asci,* 43-76μ × 6-9μ; of *stalk cells,* 13-33μ × 4-7μ; of *blastospores,* 4.5-6.5μ × 1.5-2μ.

Distribution: Oregon, British Columbia.

Material examined: OREGON: Zigzag Mountain Trail, July 9, 1929, G. D. Darker (Arnold Arboretum, Path. Herb. 186); Rhododendron, Sept. 6, 1931, J. R. Hansbrough (Herb. J. R. H. 614). BRITISH COLUMBIA: Vancouver Island, Sidney or Lake Cowichan, June, 1938, Malcolm Wilson.

In the original description of this fungus the spots are described as brown. This must have been due to age of material since in the freshly collected material received in 1938 from Malcolm Wilson, the spots were, as he kindly pointed out, lemon-yellow in color. The width of asci (4-7μ) given in the original description is in error. Examination of the measurements recorded at the time of describing shows the width to be 6-9μ as given above. Other revisions in dimensions (of stalk cells and conidia) result from study of additional material.

The fungus was named in honor of Dr. J. H. Faull, from whom it was first received. The first collection, apparently, was that of Darker in 1929.

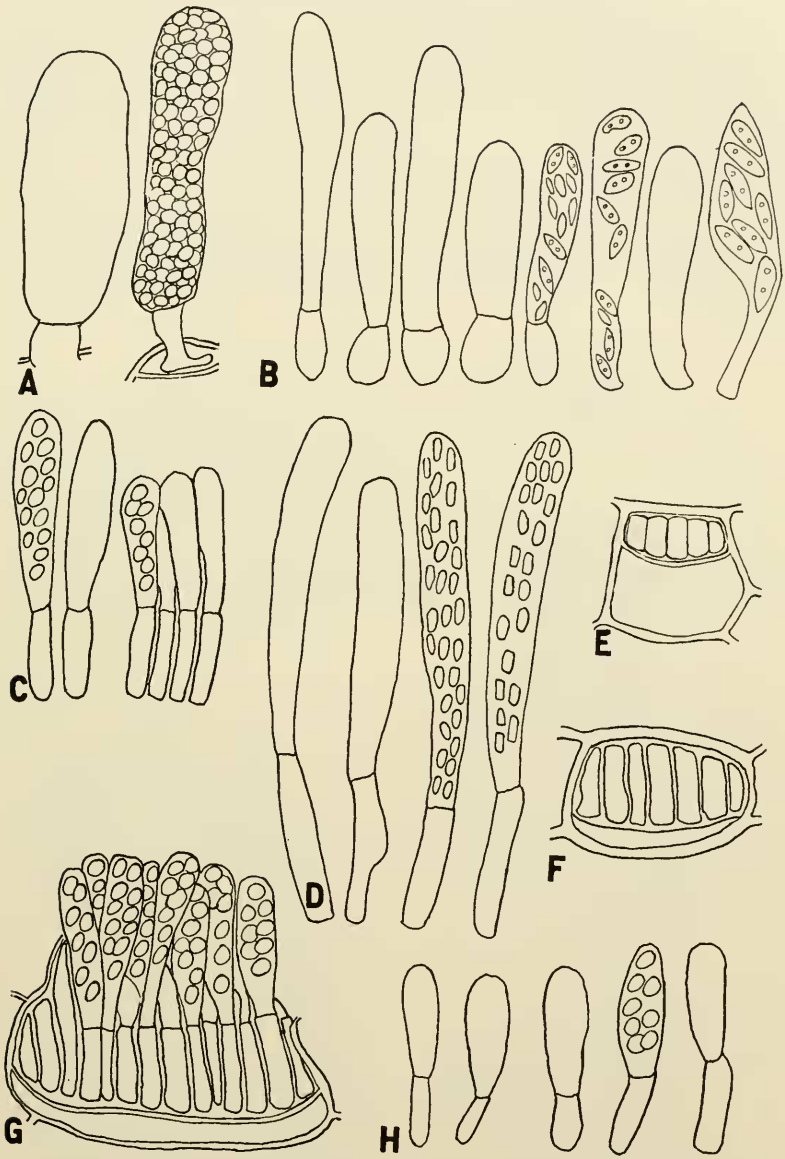

FIG. 4. Asci (×900) of A, *Taphrina higginsii;* B, *T. wettsteiniana;* C, *T. polystichi;* D, *T. faulliana;* E-H, *T. tonduziana;* E, F, ascogenous cells in wall locules; G, emerging asci; H, asci.

19. *Taphrina tonduziana* P. Hennings

Taphrina tonduziana P. Hennings, Beibl. z. Hedwigia, **41**:101-105. 1902.

Causing small (up to 5 mm. diam.) brown (with central areas whitish by presence of asci) unthickened spots on leaves of *Pteris spinosa* (L.) Desv.

Mycelium growing within the epidermal wall.

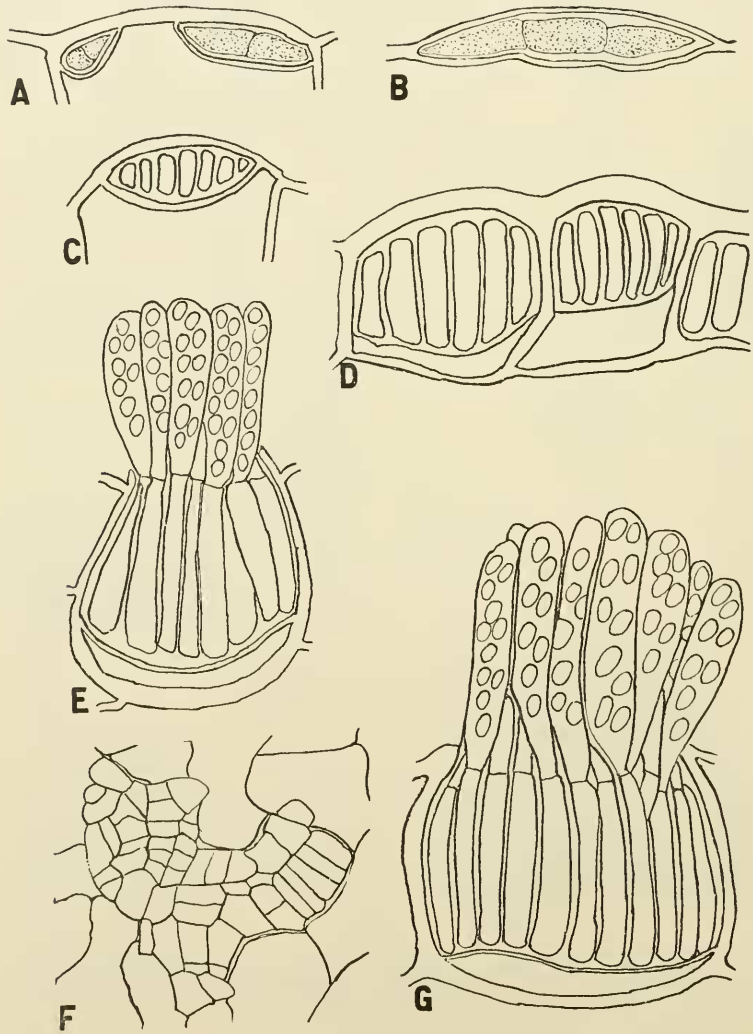

FIG. 5. A-E, *Taphrina laurencia*. A, B, mycelium in wall locule; C, D, ascogenous cells; E, asci, in wall locule; F, ascogenous cells (viewed from above), G, asci of *T. rhomboidalis*. All × 900.

Asci amphigenous, emerging from wall locules, clavate, provided with a stalk cell. Ascospores eight, long-elliptic to fusiform. (Fig. 4, E-H.)

Dimensions: Of *asci,* 20-33μ × 7-8μ; of *stalk cells,* 10-23μ × 4-7μ; of *spores,* 4-7μ × 2-3μ.

Distribution: Costa Rica.

Material examined: COSTA RICA: San José, 1900, leg. A. Tonduz, comm. P. Hennings (Rehm, Ascomyceten 1461).

The errors in the original description by Hennings have already been corrected and discussed (Mix, 1938), and the "wall habit" of the fungus described.

20. *Taphrina laurencia* Giesenhagen

Taphrina laurencia Giesenhagen, Flora **76**:130-156. 1892.

Causing remarkable, much branched, fine, bushy outgrowths on fronds of *Pteris quadriaurita* Retz.

Mycelium growing within the epidermal wall.

Asci amphigenous, emerging from wall locules, provided with a stalk cell. Ascospores oval to elliptic. (Fig. 5, A-E.)

Dimensions: Of *asci,* 23-33μ × 6-9μ; of *stalk cells,* 17-30μ × 4-7μ; of *spores,* 5-7μ × 2-4μ.

Distribution: Ceylon.

Material examined: CEYLON: Hakgala, March, 1914, T. Petch; Perideniya, 1912, T. Petch (Ex. Herb. Rehm). INDIA: G. Smith (Ex. Herb. Sydow).

The correction of Giesenhagen's report that asci form within the epidermal cells has been made earlier (Mix, 1938). Giesenhagen did not find spores when describing the fungus but later (1901) reported them to be in size near those of *Taphrina vestergrenii.* Spores were present in the material examined by the writer.

21. *Taphrina rhomboidalis* Sydow and Butler

Taphrina rhomboidalis Sydow and Butler, Ann. Myc. **9**:372-421. 1911.

Causing small yellow (becoming brown with age) rhomboidal unthickened spots on leaves of *Pteris quadriaurita* Retz.

Mycelium growing within the epidermal wall.

Asci amphigenous, emerging from wall locules, provided with a stalk cell; ascospores eight, ovate to elliptic. (Fig. 5, F, G.)

Dimensions: Of *asci,* 23-43μ × 8-10μ; of *stalk cells,* 23-43μ × 4-5μ; of *spores,* 4-7μ × 2-3.5μ.

Distribution: Northern India.

Material examined: HIMALAYA: Kumaon, Barma Gori Valley, June 24, 1907, Inayat Khan. Det. E. J. Butler. (Imp. Agric. Res.

Inst. I. 47.) Received from G. Watts Padwick, Imp. Agric. Res. Inst. New Delhi, India.

The rhomboidal shape of the lesion is due to its being margined by veins, though commonly more than one vein-islet is included. The "wall habit" of the fungus, not fully described by the original authors, has been discussed earlier (Mix, 1939) as well as the differences between this species and the preceding. These are: the production of unthickened spots instead of branched outgrowths, the irregular, rather than polyhedral, outline of ascogenous cells when viewed from above, and the possession by the ascus of a somewhat narrower stalk cell.

22. *Taphrina amplians* Mix

Taphrina amplians Mix, Mycologia **31**:445-454. 1939.

Causing marked enlargement, but no thickening, of pinnae or pinnules of *Pteris orizabe* Mat. and Gal. Affected areas becoming golden-brown.

Mycelium growing within the epidermal wall.

Asci amphigenous, emerging from wall locules, golden-yellow before maturity, and containing yellow material in epiplasm after spore formation, provided with a stalk cell; ascospores eight, ovate to elliptic. (Fig. 6. A, B.)

Dimensions: Of *asci,* 26-36μ × 8-10μ; of *stalk cells,* 23-40μ × 5-8μ; of *spores,* 5-6.5μ × 2-3μ.

Distribution: Guatemala.

Material examined: GUATEMALA: Quetzaltenango: Santa Maria de Jésus, Dec. 28, 1936, J. H. Faull (Herb. J. H. F. 12939).

In studying material of *Taphrina uleana* (P. Henn.) Gies. the writer was struck with the similarity of the healthy fronds of the host to those of *Pteris orizabe,* and of the resemblance of the lesions to those caused by *T. amplians.* This raised the question whether the two hosts and perhaps the two fungi might be identical.

The ferns were submitted to C. A. Weatherby of the Gray Herbarium, who compared them with authentic herbarium-specimens. The host for *Taphrina uleana* is not *Pteris decurrens* Presl. as reported by Hennings but *Pteris deflexa* Lk. *Pteris deflexa* and *Pteris orizabe* are distinct, though closely related species, with different geographical distribution.

The following specimens of *Taphrina uleana* were carefully studied: 1. Museum botanicum Berolinense. E. Ule. Herbarium Brasiliense No. 3076. *"Taphrina (Exoascus) Uleana* P. Henn. Auf *Pteris decurrens,* Estado de Rio de Janciro, wald bei Tijuca, Marz.

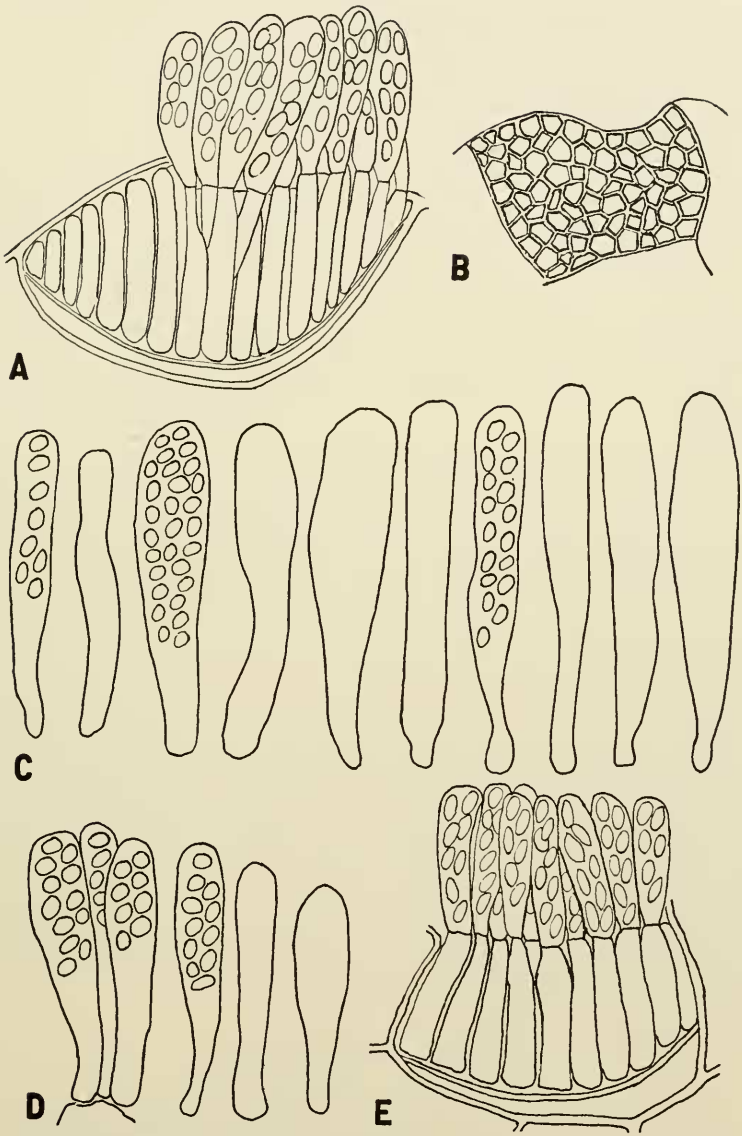

FIG. 6. A, Asci, B, ascogenous cells (from above) of *Taphrina amplians;* C, D, asci of *T. lutescens;* E, asci of *T. pteridis* in wall locule. All × 900.

1900. leg. E. Ule. Typus!" 2. Six packets of: Mycotheca brasiliensis, No. 86, "*Taphrina uleana* P. Henn. in pterid. decurr. Rio de Jan. Tijuca, 1900 E. Ule." Three of these packets were seen in the Farlow Herbarium and three in the Botanical Museum, Stockholm. One of the packets in the Farlow Herbarium is further designated, "Ex. Museo. Botanico Berolinense. Original."

The herbarium-sheet bearing the packet of type material (1, above) has affixed to it a portion of Henning's paper (1904) giving a short Latin diagnosis, and a German description, translated as follows: "Whole leaves or large areas affected by the fungus, they are at first thin membranous, yellowish, later thicken somewhat and become stiff and dirty brown. Unfortunately could only find occasional asci with ripe spores, therefore possible that size of asci may be different: Not precluded that the species better placed in *Taphrina.*"

Most of this material is abominable. It gives the appearance of having been wet and then dried without pressing. The type material is the worst of all. In one of the packets in the Farlow Herbarium the healthy portions of the fronds are well preserved and it can be seen that the diseased areas are enlarged, but not thickened, and browned. This, together with the description quoted above, suggests that *Taphrina amplians* and *T. uleana* may be similar fungi.

Thorough study of all available material of *T. uleana* has failed to reveal any mycelium or asci of *Taphrina,* any wall locules (even empty) such as are produced by *T. amplians,* anything in fact, but empty host cells and spores and mycelium of various molds. Study of the type specimen was made before writing the description of *T. amplians;* of the other specimens later. It seems posisble that the writer may have described (as *T. amplians*) a fungus related to or even identical with *T. uleana.* Since, however, the type specimen of *Taphrina uleana* does not show any recognizable fungus, *Taphrina uleana* must be declared a *nomen dubium.*

23. *Taphrina pteridis* Viégas

Taphrina pteridis Viégas, Bragantia 4:5-392. 1944.

Causing small (3-4 mm. diam.) round to elliptic (sometimes angular) yellowish to brown, necrotic spots on leaves of *Pteris* sp.

Mycelium growing within the epidermal wall.

Asci amphigenous, clavate, rounded at apex, emerging from wall locules; stalk cells cylindric; ascospores eight, elliptic. (Fig. 6, E.)

Dimensions: Of *asci,* 16-26μ; *stalk cells,* 8-20μ × 6-7μ; of *ascospores,* 4-7μ × 2.5-3μ.

Distribution: Campinas, São Paulo, Brazil.

Material examined: Brazil: São Paulo, Campinas, Bosque dos Jequitibas, June 12, 1943, A. P. Viégas and R. O. Botero (part of type, received from Viégas).

The mycelium of this fungus is not subcuticular, as stated by Viégas (l. c.), but develops within the epidermal wall, the mature asci protruding from a wall locule.

24. *Taphrina lutescens* Rostrup

Taphrina lutescens Rostrup, Meddel. Naturh. Foren. **1890**. 246-264.
Magnusiella lutescens (Rostr.) Sadebeck. Jahrb. Hamburg Wissensch. Anst. **10**:5-110. 1893.

Causing small (up to 3 mm. diam.) pale yellow unthickened spots (the central portion becoming covered with a layer of asci), on leaves of *Thelypteris thelypteris* (L.) Nieuwl.

Mycelium intercellular.

Asci hypophyllous, clavate, rounded at apex, lacking a stalk cell; ascospores eight, ovate to elliptic, commonly budding within the ascus, filling it with bacterioid blastospores. (Fig. 6, C, D.)

Dimensions: Of *asci,* 27-75μ × 5-11μ (average 40μ × 7μ); of *ascospores,* 3-6μ×2-4μ (average 4μ×2.6μ); of *blastospores,* 1.5-3μ× 1.5-2μ.

Distribution: northeastern United States and adjacent Canada, northern Europe.

Material examined: Maine: York, Aug., 1897, R. Thaxter. New York: Shelter Island, Aug., 1901, Herb. W. G. Farlow. Wisconsin: Madison, July 20, 1943, H. C. Green. Denmark: Seeland, Gjorslev, July, 1889, E. Rostrup; Lyngby, July, 1909 (received from J. Dearness). Germany: Schleswig-Holstein, Pugum near Glucksberg, July 13, 1908, O. Jaap (Fungi sel. exsicc. 304); Zahlendorf near Berlin, Sept., 1901, Sydow (Rehm, Ascomycetes 1413). Latvia: Leinzale, Milskabe, Aug. 5, 1934, A. Kirulis (Fungi latvici 652).

HOST INDEX TO SPECIES OF *TAPHRINA* ON FERNS

Athyrium filix-femina Roth.
    Taphrina athyrii Siemaszko
Blechnum sp.
    Taphrina blechni Bresadola ex Mix
Cystopteris fragilis (L.) Bernh.
    Taphrina cystopteridis Mix
Dryopteris arguta (Kaulf.) Wats.
    Taphrina californica Mix
Dryopteris cheilanthoides (Kze.) C. Chr.
    Taphrina ecuadorensis Syd.
Dryopteris filix-mas Schott.
    Taphrina vestergrenii Gies.

Dryopteris lacera O. Kuntze.
Taphrina vestergrenii Gies.
Dryopteris marginalis (L.) A. Gray.
Taphrina gracilis Mix
Dryopteris poiteana (Bory) Urban
Taphrina thaxteri Mix
Dryopteris rigida (Hoffm.) Underw.
Taphrina fusca Gies.
Dryopteris rigida var. *australis* Christ.
Taphrina fusca Gies.
Dryopteris spinulosa (Muell.) Kuntze
Taphrina athyrii Siemaszko
Taphrina filicina Rostr. ex Johans.
Taphrina fusca Gies.
Dryopteris spinulosa var. *americana* (Fisch.) Fern.
Taphrina filicina Rostr. ex Johans.
Taphrina fusca Gies.
Dryopteris spinulosa var. *intermedia* Underw.
Taphrina filicina Rostr. ex Johans.
Taphrina fusca Gies.
Dryopteris sp.
Taphrina fasciculata (Lagerh. and Sadeb.) Gies.
Onoclea sensibilis L.
Taphrina hiratsukae Nishida
Osmunda cinnamomea L.
Taphrina higginsii Mix
Osmunda regalis L.
Taphrina osmundae Nishida
Polystichum acrostichoides (Michx.) Schott.
Taphrina polystichi Mix
Polystichum aristatum Presl.
Taphrina cornu-cervi Gies.
Polystichum lonchitis (L.) Roth.
Taphrina wettsteiniana Herzf.
Polystichum munitum (Kaulf.) Prsl.
Taphrina faulliana Mix
Pteretis nodulosa (Michx.) Nieuwl.
Taphrina hiratsukae Nishida
Pteretis struthiopteris (L.) Todaro
Taphrina hiratsukae Nishida
Pteris orizabe Mat. and Gal.
Taphrina amplians Mix
Pteris quadriaurita Retz.
Taphrina laurencia Gies.
Taphrina rhomboidalis Syd. and Butl.
Pteris spinosa (L.) Desv.
Taphrina tonduziana P. Henn.
Pteris sp.
Taphrina pteridis Viégas
Thelypteris thelypteris (L.) Nieuwl.
Taphrina hiratsukae Nishida
Taphrina lutescens Rostr.

II. SPECIES ON SALICACEAE

Populus and *Salix*

25. *Taphrina populina* Fries

Taphrina populina Fries, Syst. Mycol. 3:520. 1832.
Taphrina aurea auct.
Exoascus populi Thümen, Hedwigia 13:97-98. 1874.
Exoascus aureus Sadebeck, Jahrb. Hamburg. Wissensch. Anst. 1:93-124. 1884.
Exoascus flavo-aureus Cocconi, Mem. R. Accad. Sci. Inst. Bologna 4:187-198. 1894.

Causing golden yellow, convex-concave spots, often small (5-10 mm. diam.), but sometimes confluent and large, involving half or nearly all of leaf blade, on *Populus angulata* Ait., *P. balsamifera* L., *P. berolinensis* Dipp., *P. ciliata* Wallr., *P. generosa* Henry, *P. laurifolia* Ledb., *P. nigra* L., *P. nigra* L. var. *italica* Dur., *P. petrowskyana* Schneid., *P. rasomowskyana* Schneid.

Mycelium intercellular.

Asci variable in form, cylindric or clavate, rounded or truncate at the apex, narrowed toward the base. Stalk cell present or absent, variable in form, often triangular, wedge-shaped, or bluntly rounded. Asci inserted between epidermal cells for as much as one-third of their lengths. Asci when young with yellow oily contents, large yellow globules persisting after spore formation. Ascospores rarely seen; then commonly four, budding immediately so that mature asci are filled with numerous blastospores. (Fig. 7, A-E, Fig. 8, A-C.)

Dimensions: Of *asci,* 30-122μ × 13-30μ; of *stalk cells* (when present) 4-27μ × 8-23μ; of *ascospores,* 4-6.5μ×4-5μ; of *blastospores,* 2-3μ × 2.5-1.5μ. Minute bacterioidal blastospores occasionally seen.

Distribution: widely distributed in Europe, locally throughout eastern North America, occasionally western North America, known also from India, China, and Japan.

Material examined: Populus angulata. Germany: Brandenburg, Späthsche Baumschulen zu Rixdorf b. Berlin, July 24, 1903, H. and P. Sydow (Myc. Germ. 28).

P. balsamifera. ibid. (Myc. Germ. 28.) Norway: Akershus, Ås, 1885, F. Werenskiold.

P. berolinensis. Iowa: Ames, June 20, 1892, Pammel and Stewart (as on *P. "certinensis"*). Norway: Akershus, Finsen in Aker (in nursery), Sept. 10, 1931, I. Jørstad.

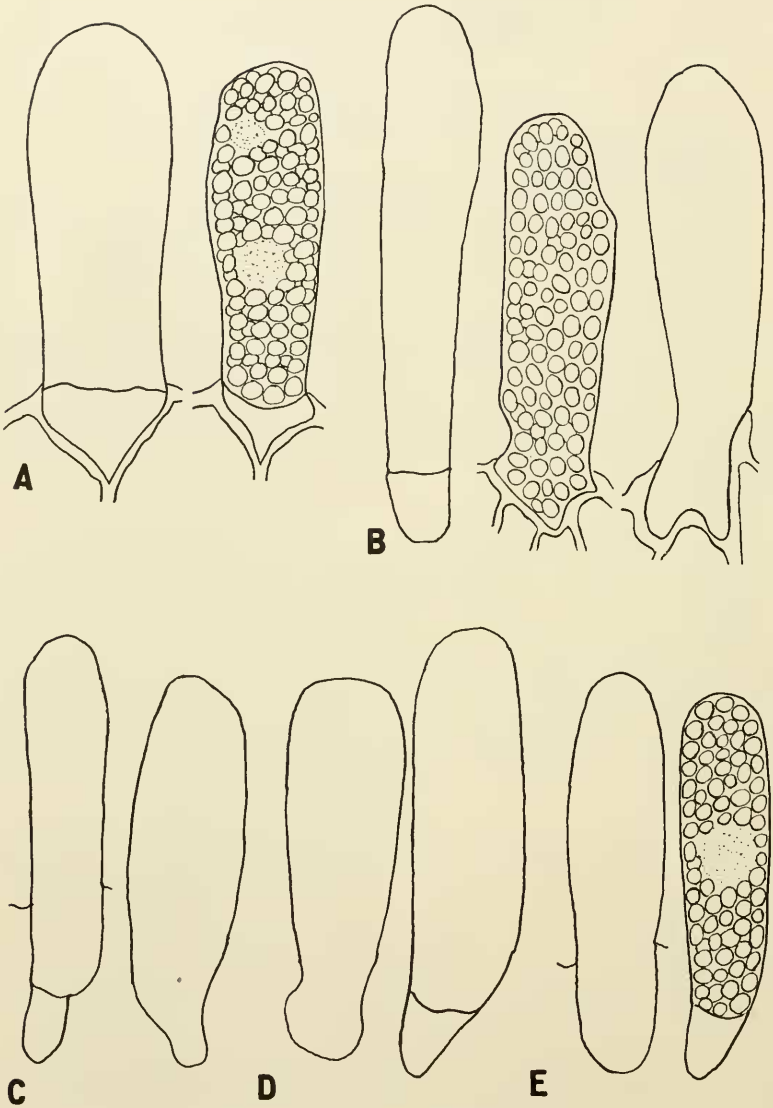

FIG. 7. Asci (× 900) of *Taphrina populina*. A, on *Populus angulata;* B, *P. balsamifera;* C, *P. berolinensis;* D, *P. ciliata;* E, *P. generosa.*

P. ciliata. India: Murree, July 20, 1908, E. J. Butler (Herb. Crypt. Orient. Fungi).

P. generosa. Norway: Akershus, Ås (in nursery) June 15, 1925, I. Jørstad. Scotland: Murthly, July 15, 1925, J. S. Boyce (Herb. J. S. B. 1565a); *ibid.* (Herb. J. S. B. 1565b).

P. nigra. Iowa: Ames, June 20, 1892 (as on *P. "betulifolia"*). Washington: Bremerton, July 20, 1912, E. Bartholomew (Fungi Columb. 4488). West Virginia: Hillsboro, June 11, 1935, C. R. Orton (as on *P. "nigra* var. *babylonica"*). Austria: between Mossbrunnen and Marienthal, June, von Höhnel (Mus. Palat. Vindob. Krypt. Exsicc. 1718). Italy: Venezia (Myc. Ital. 533). Poland: Skiernewice, July 5, 1923, Z. Zweigboumawna. Scotland: Murthly, July 15, 1925, J. S. Boyce (Herb. J. S. B. 1565c). Sweden: Skåne: Ystad, Bergsjöholmgård, July, 1939.

P. nigra var. *italica.* Iowa: Ames, June 20, 1892, L. H. Pammel (as on *"P. fastigiata"*). Oregon: Portland, June 16, 1931, J. R. Hansbrough (Herb. J. R. H. 610). Vermont: Duxbury, July 18, 1929, P. Spaulding (Herb. P. S. 66776). British Columbia: Revelstoke, Sept. 7, 1930, J. R. Hansbrough (Herb. J. R. H. 610). Quebec: Sillery, May 8, 1936, R. Pomerleau. Germany: Brandenburg, Späthsche Baumschulen zu Rixdorf b. Berlin, July 24, 1903, H. and P. Sydow (Myc. Germ. 30).

P. petrowskyana. Iowa: Ames, June 20, 1892, F. C. Stewart.

P. rasomowskyana. Germany: Dahlem b. Berlin, July, 1902, P. Hennings (Rehm, Ascomyceten 273b).

The occurrence of a stalk cell in *Taphrina populina* was first reported by Frank (1880) and later by Johanson (1887). The existence of a stalk cell was denied by Sadebeck (1890), but as pointed out by Johanson, Sadebeck had confused this fungus with *Taphrina rhizophora.* Sadebeck later (1893) distinguished two types of asci in *T. populina:* (1) Slender, deeply inserted asci, 80-112μ × 20-27μ, provided with stalk cells and occurring on *Populus nigra* L. var. *italica* Dur.; and (2), broad asci, 80μ × 30-40μ, slightly inserted, often lacking stalk cells, occurring on *Populus nigra* L. The fact that the stalk cell may be present or absent has been recorded by most later investigators.

In these studies the two types of asci mentioned by Sadebeck have been found on all but one of the hosts listed above. Asci without stalk cells may have a bluntly rounded or wedge-shaped base, and are less deeply inserted than the longer asci with stalk cells. Neither type of ascus occurs exclusively on any one host. In particular the limits of ascus-size observed for *Populus nigra* are: 30-122μ ×

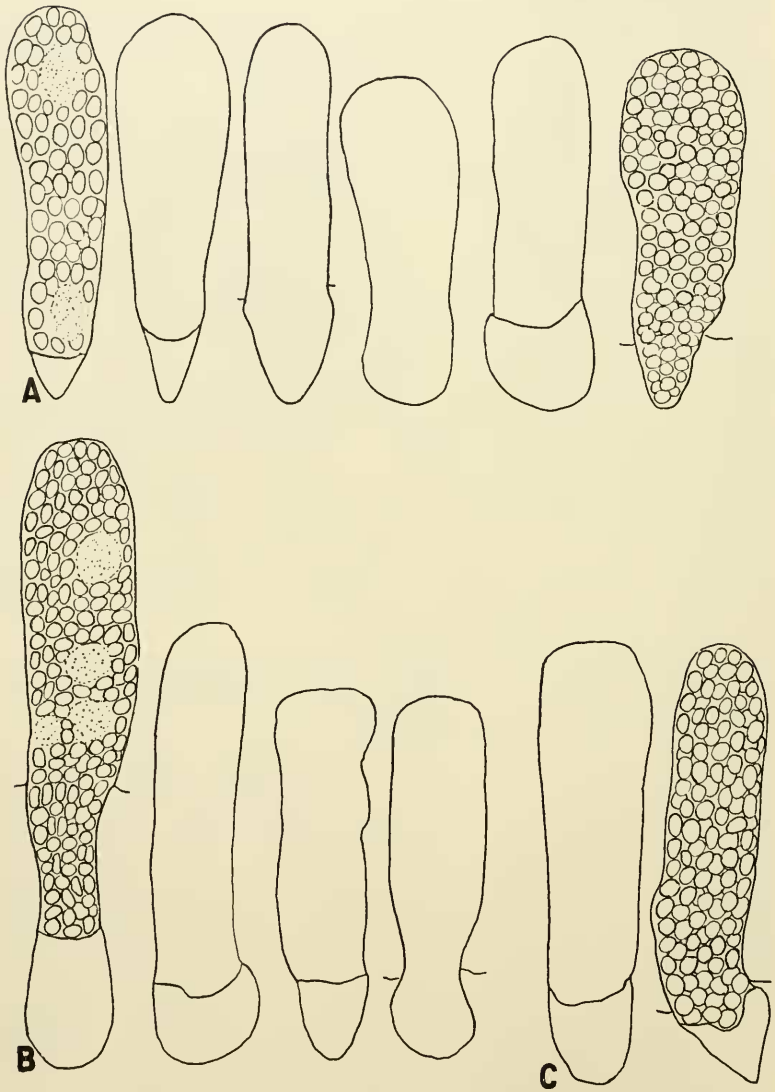

FIG. 8. Asci (×900) of *Taphrina populina*. A, on *Populus nigra;* B, *P. nigra* var. *italica;* C, *P. rasomowskyana.*

16-30μ, and for *P. nigra* var. *italica:* 42-109μ × 15-30μ. (More specimens of the former have been studied.) Asci with stalk cells seem equally common on both hosts. Incidentally no asci as wide as those reported by Sadebeck have been observed.

A further example of the variability of *Taphrina populina* appears in the attempt by Cocconi (1894) to erect a new species, *Exoascus flavo-aureus* for the fungus on *P. nigra* var. *italica.* It possesses, according to his observations, a tapering, rhizoidal ascus-base, inserted between the epidermal cells of the host.

The following is a record of the writer's studies of *Taphrina populina* on the various host-species listed above:

Host	Ascus dimensions in microns	Presence of stalk cell	Stalk cell dimensions in microns
Populus angulata Ait.	33-76 × 20-27	+	10-23 × 10-20
Populus balsamifera L.	63-116 × 17-26	+ or —	8-20 × 10-20
Populus berolinensis Dipp.	43-80 × 17-26	+ or —	8-17 × 10-22
Populus ciliata Wallr.	73-122 × 23-33	+ or —	7-10 × 17-23
Populus generosa Henry	56-76 × 16-20	+ or —	8-10 × 10-13
Populus laurifolia Ledeb.	33-83 × 16-26	+ or —	8-20 × 10-16
Populus nigra L.	30-122 × 15-30	+ or —	5-26 × 10-20
Populus nigra L. var. *italica* Dur.	40-109 × 15-30	+ or —	10-30 × 10-20
Populus petrowskyana Schneid.	43-76 × 13-26	+ or —	10-23 × 13-20
Populus rasomowskyana Schneid.	35-86 × 17-30	+ or —	7-30 × 10-20

Choosing the fungus on *P. nigra* as the type, it might be possible to distinguish varieties, one for each host-species. The danger in this would be that if additional specimens were studied some of the differences evident here might disappear. In the absence of information as to the biological specialization it seems best merely to record that *Taphrina populina* shows marked variability on different hosts.

26. *Taphrina populi-salicis* Mix

Taphrina populi-salicis Mix, Trans. Kansas Acad. Sci. **50**:77-83. 1947.

Causing golden-yellow convex-concave spots on leaves of *Populus fremontii* S. Wats., *P. trichocarpa* Torr. and Gray, and *Salix laevigata* Bebb.

Mycelium intercellular.

Asci hypophyllous, oblong-cylindric, rounded at the apex. Stalk cell invariably present, short and wedge-shaped or long and tapering, often forked, deeply inserted in leaf tissues. Spores (blastospores) numerous, elliptical, ovate, or narrowly elongate. (Fig. 9, A, C, Fig. 10, A, B.)

Dimensions: Of *asci,* 50-106μ × 13-30μ; of *stalk cells,* 7-92μ × 7-27μ; of *spores,* 1.5-5μ × 0.5-4.5μ.

Distribution: Pacific Coast States.

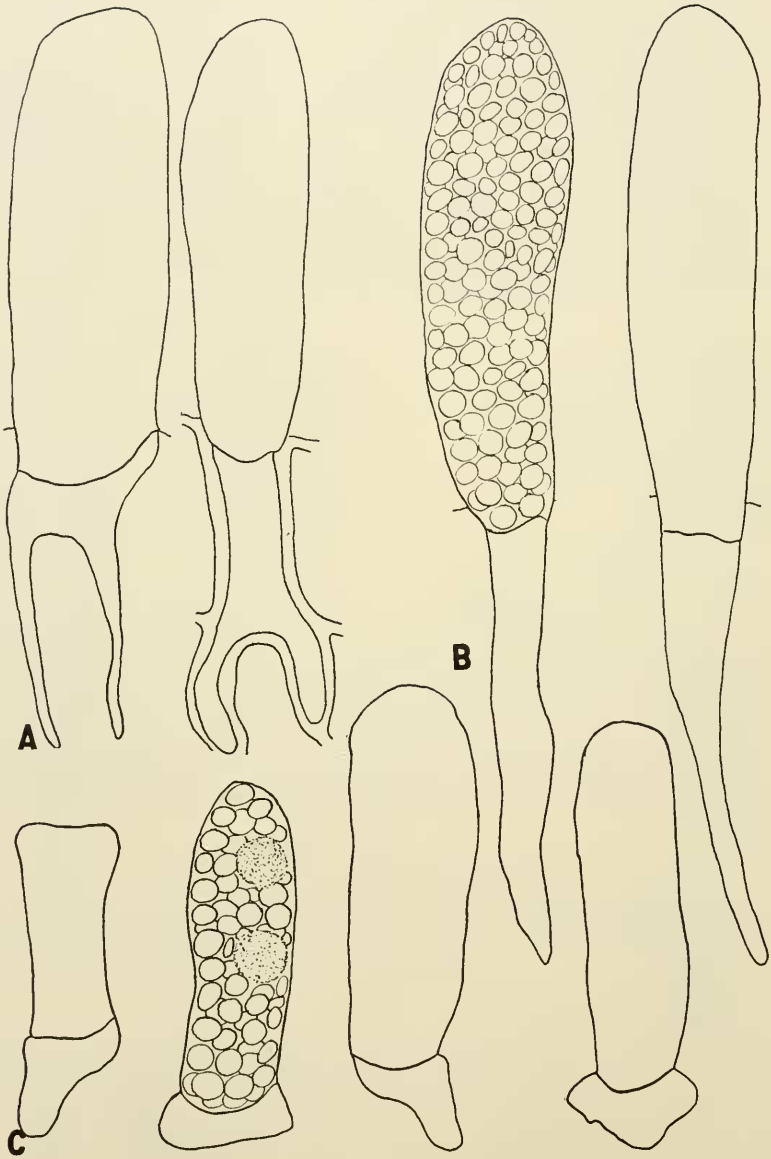

FIG. 9. Asci (× 900) of *Taphrina populi-salicis.* A, on *Populus fremontii;* B, C, *P. trichocarpa.*

Material examined: P. fremontii. California: Berkeley, July 10, 1938, H. N. Hansen; Palo Alto, San Francisquito Creek, May 13, 1941, R. H. Thompson; Sacramento, June 8, 1924, H. E. Parks and W. S. Fields.

P. trichocarpa. California: Glendale, May, 1897, A. J. McClatchie (Fungi Columb. 1228); Palo Alto, April 17, 1940, R. H. Thompson; Richardson Grove, Aug. 22, 1929, G. D. Darker. Oregon: Lane Co., Eula, June 13, 1920, J. S. Boyce (Herb. J. S. B. 594); Portland, Aug. 12, 1931, J. R. Hansbrough (Herb. J. R. H. 609). British Columbia: New Westminster, July, 1938, Malcolm Wilson; Owl Creek, June 24, 1931, J. R. Hansbrough and T. S. Buchanan (Herb. J. R. H. 608).

Salix laevigata. California: Lassen Co., Mineral, Sept. 10, 1911, E. P. Meinecke (Herb. J. S. B. 282).

This fungus, while causing leafspots quite like those caused by *Taphrina populina* shows definite morphological differences, and an apparent biologic distinction, from that species. Boyce (1927) reports observing in the Pacific northwest that *Populus nigra* often is not attacked in the same locality in which *P. trichocarpa* is affected, and that in a nursery in Scotland, in 1925, *Taphrina populina* attacked *Populus generosa, P. laurifolia,* and *P. nigra* (the last named being the most heavily infested), while *P. trichocarpa* growing with its leaves intermingling with those of the diseased *P. generosa* remained healthy.

It is of interest that indigenous west coast species of *Taphrina* described by Mix (1939) and Ray (1939) are different from related forms found in the eastern United States. (*Taphrina populina* was undoubtedly introduced into this region along with its host.)

27. *Taphrina johansonii* Sadebeck

Taphrina johansonii Sadebeck, Jahrb. Hamburg. Wissensch. Anst. **8**:61-95. 1890.
Taphrina rhizophora Johanson, Bih. t.k. Svensk Akad. Handl. **13**:3-28. 1887, in part.
Exoascus johansonii Sadebeck, Jahrb. Hamburg. Wissensch. Anst. **10**:5-110. 1893.
Exoascus aureus auct.

Causing golden-yellow enlargements of carpels of *Populus canescens* Reichenb., *P. grandidentata* Wats., *P. sieboldii* Miq., *P. tremula* L., *P. tremula* var. *pendula* Loud., *P. tremuloides* Michx.

Mycelium intercellular.

Asci elongate, clavate, rounded at apex, with no stalk cell but with a tapering base deeply inserted between host cells; when young with

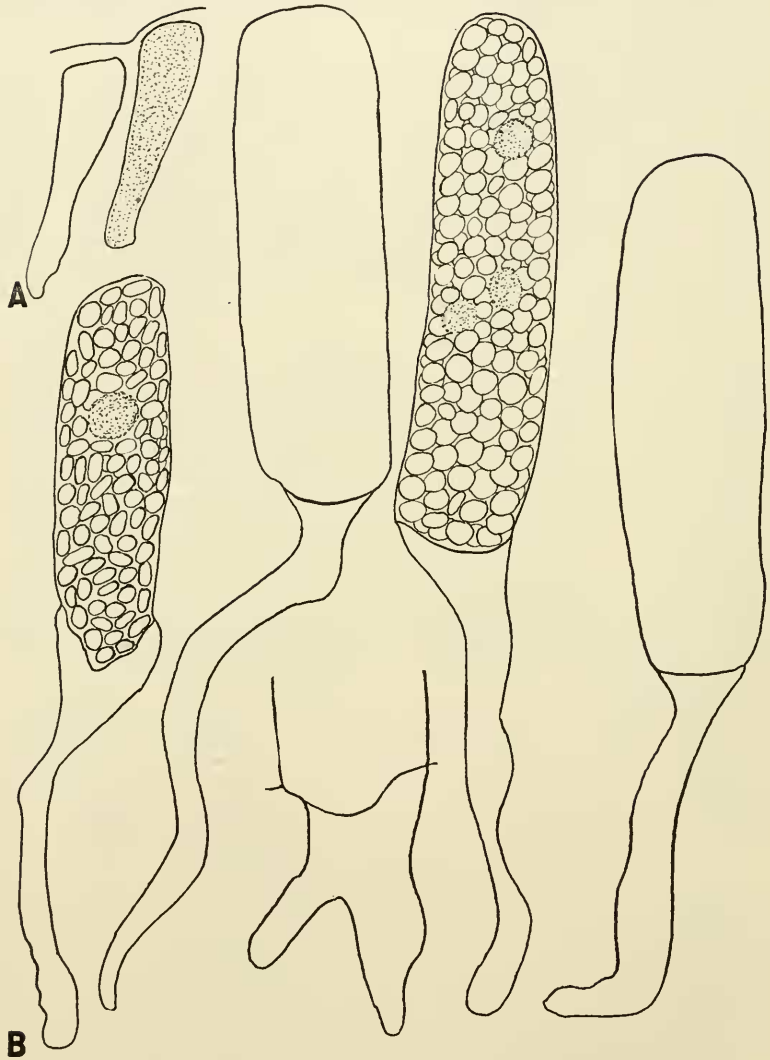

FIG. 10. *Taphrina populi-salicis.* A, ascogenous cells on *Populus trichocarpa;* B, asci on *Salix laevigata.* ×900.

yellow oily contents, yellow oil globules persisting after spore formation; ascospores rarely seen, budding at once to fill the ascus with numerous blastospores which are variable in form: oval, fusiform, or rod-shaped. (Fig. 11, A-E.)

Dimensions: Of *asci,* 60-145μ × 12-27μ, narrowing at the foot to a width of 3 to 10μ, inserted for about one-third (occasionally one-half) the ascus-length; of *ascospores,* 4-7μ × 4-6μ; of *blastospores,* 4-10μ × 1.5-4μ.

Distribution: Europe, eastern North America, Japan.

Material examined: P. canescens. Russia: Moscow, O. L. Park, June, 1893, P. Sydow (Myc. March. 3820).

P. grandidentata. Massachusetts: Peabody, April 19, 1938, D. H. Linder.

P. sieboldii. Japan: Morioka, Kaminoyai, May 24, 1908 (Herb. Morioka Imp. Coll. Agric. and For.).

P. tremula. Denmark: Jylland, Viborg, May 28, 1890, C. A. Gad (Fungi Scand., Gunnar V. Schotte); Firesö, Sj. Koningaarden, May 6, 1894, F. Kølpin Ravn. Finland: Helsingfors, May, 1903, J. I. Liro (Vestergren, Micr. Rar. Sel. 1619).

P. tremula var. *pendula.* Sweden: Stockholm, Hortus Bergianus, June 7, 1924, T. Vestergren.

P. tremuloides. Massachusetts: Medford, April 25, 1891, A. B. Seymour and Agnes W. Lincoln (Seymour and Earle, Econ. F. 191 as *T. rhizophora*); Wellesley, May 20, 1935, D. H. Linder. Michigan: between Brighton and Whitmore Lake, May 24, 1935, L. E. Wehmeyer; near Mich. Agric. Coll., May, 1892 (N. A. F. 1885, F. Columb, 1312, as *T. rhizophora*). New York: Ithaca, Kline Woods Road, May 22, 1940, A. J. M.; Connecticut Hill, May 28, 1940, P. A. Readio. Wisconsin: Racine, F. L. Stevens (F. Columb. 407, as *T. rhizophora*).

Species on the carpels of *Populus* were not at first distinguished from *Taphrina populina* (*T. aurea*). Thus Farlow (1878) reported *T. aurea* on carpels of *P. grandidentata.* Following the description of *T. rhizophora* on carpels of *P. alba* by Johanson (1887) American authors accepted that name.

Farlow (1888) lists as occurring in North America: *T. rhizophora* on carpels of *P. fremontii, P. grandidentata, "P. pyramidalis,"* and *P. tremuloides.* The record on *P. fremontii* seems to be an error, referring to a collection of *T. populi-salicis* on leaves of that host. *"P. pyramidalis"* is a varietyof *P. alba,* but the writer has been unable to find any record of such a collection made in North America.

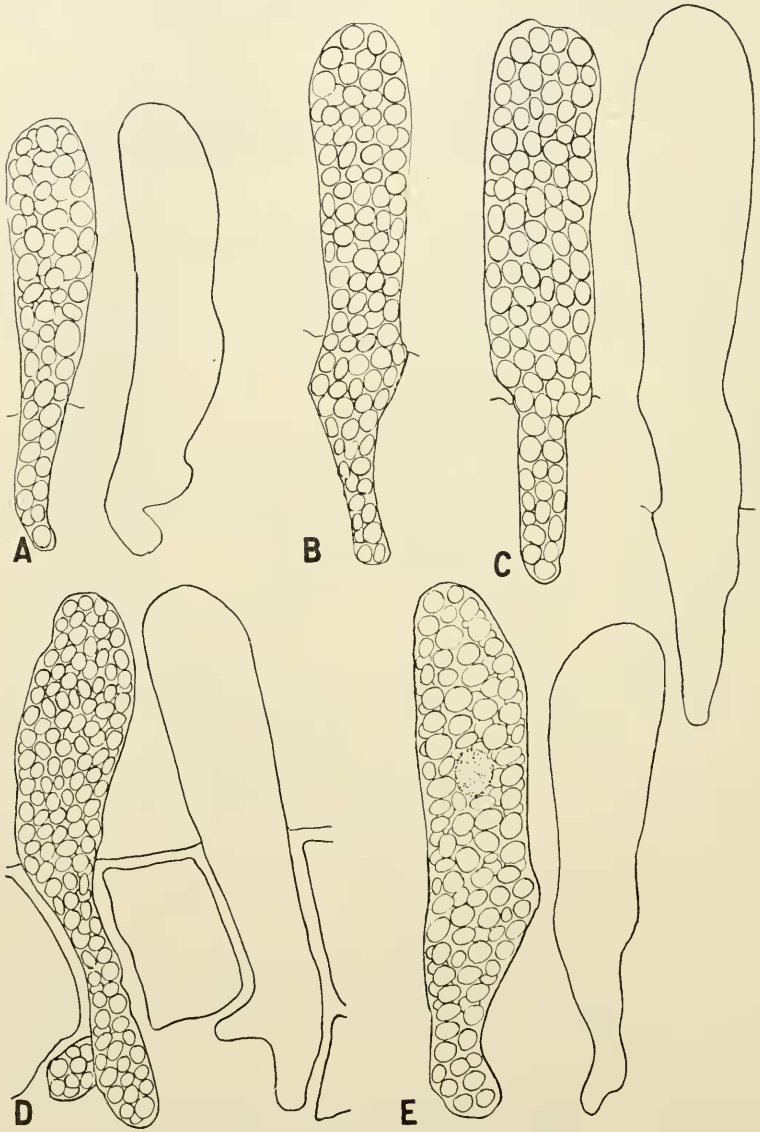

FIG. 11. *Taphrina johansonii.* Asci (× 900), A, on *Populus tremula;* B, *P. canescens;* C, *P. sieboldii;* D, *P. tremuloides;* E, *P. grandidentata.*

Farlow's fungus should have been reported as *Taphrina johansonii*. This was pointed out by Patterson (1895) following the description of *T. johansonii* by Sadebeck (1890). Sadebeck, who earlier (1884) had called this fungus *Exoascus aureus*, described it as having asci 92-105μ long, inserted but never showing rhizoidal forking, it being distinguished by these characters from *T. rhizophora* whose asci were 120-160μ long and often showed rhizoidal extensions of the ascus-base.

The studies reported here, although they extend the limits of ascus-size beyond those reported by Sadebeck, reveal no significant differences between the forms on the various hosts listed above. The ascus-dimensions observed are: For *P. canescens*, 60-125μ × 17-26μ; for *P. grandidentata*, 66-122μ × 13-23μ; for *P. sieboldii*, 60-120μ × 17-26μ; for *P. tremula*, 60-145μ × 17-27μ; for *P. tremuloides*, 60-125μ × 16-26μ. All these host-forms show asci deeply inserted and possessing a rhizoidal foot, occasionally branched. Clearly they are all *Taphrina johansonii*.

Ikeno (1901) studying a form on *Populus tremula* var. *villosa* Wesm. considered it to be intermediate between *T. johansonii* and *T. rhizophora*, its asci measuring 83-133μ × 20-27μ and penetrating the host for from 17-20μ. He did not observe any rhizoidal extensions and on this basis decided to call it *T. johansonii*. Its dimensions fall within the limits of ascus-size for *T. johansonii* on *P. tremula* as given above.

28. *Taphrina rhizophora* Johanson

Taphrina rhizophora Johanson, Bih. t. K. Svensk. Vetensk. Akad. Handl. **13**:3-28. 1887.
Taphrina aurea auct. in part.
Exoascus aureus auct. in part.
Exoascus rhizophorus (Johans.) Sadebeck, Jahrb. Hamburg. Wissensch. Anst. **10**:5-110. 1893.

Causing golden-yellow enlargements of carpels of *Populus alba* L.

Mycelium intercellular.

Asci long, clavate, rounded at apex, attentuate at the base to a long, rhizoidal, often forking end, deeply inserted (as much as half the ascus-length) between host-cells. Young asci with yellow contents; yellow globules persisting after spore-formation. Ascospores rarely seen, budding at once to form numerous small blastospores, filling the ascus. (Fig. 12, A).

Dimensions: Of *asci*, 76-198μ × 20-30μ, tapering portion 2-10μ in diam.; *ascospores* reported by various authors as round with a diameter of 4μ; *blastospores*, 3.5-5μ × 3-4μ.

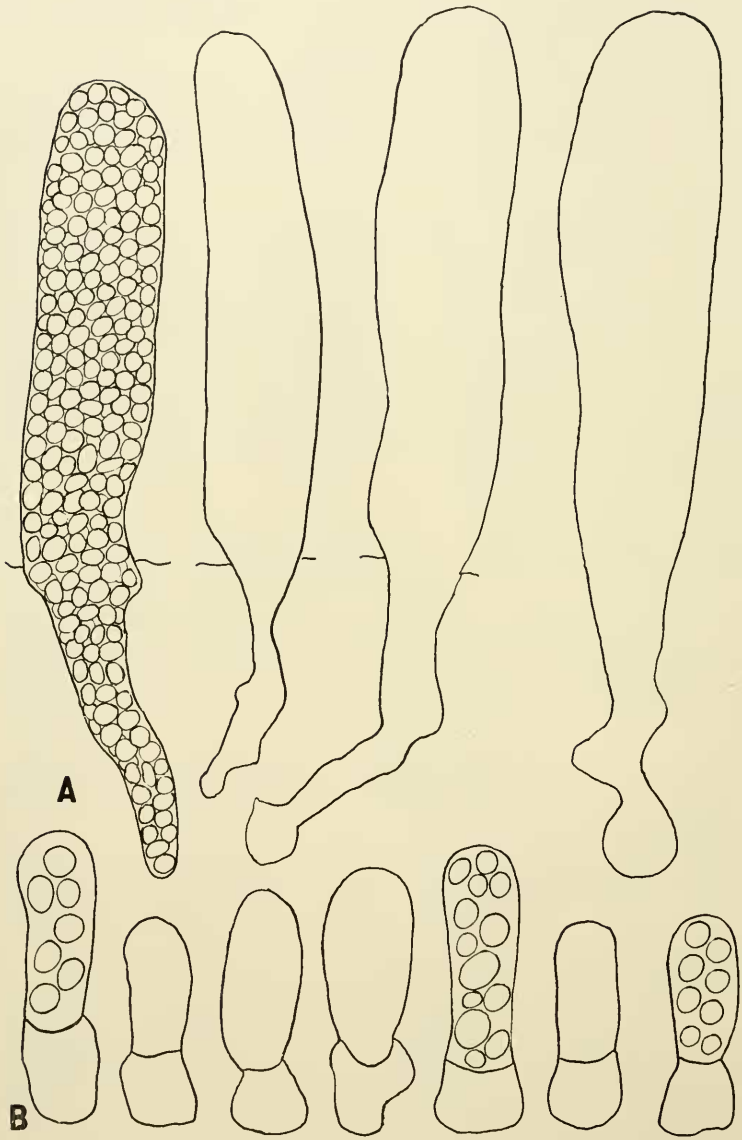

FIG. 12. Asci (× 900) of A, *Taphrina rhizophora;* B, *T. coryli.*

Distribution: Europe.

Material examined: Populus alba. Algier: Teniet-el-Had, April 20, 1930, R. Maire (Herb. R. M., Champ. Afr. d. Nord. 9933, on *P. alba* var *"hickeliana"*). Poland: Pulawy, May 4, 1930, K. Jankowska (Herb. Inst. Phytopath. Schol. Sup. Agric. Warsaw). Sweden: Skåne, Alnarp, May 19, 1890, F. Ulrichsen (Ericksson, F. Par. Scand. 358, as on *Populus* sp. but probably on *P. alba*).

The first mention of a form of *Taphrina* on the carpels of *Populus alba* and of *P. tremula* is by Magnus (1874) who called it *Taphrina aurea.* Sadebeck (1884) considered the fungi on leaves and on carpels of *Populus* to be the same, calling them *Exoascus aureus.* Johanson (1887) described the form occurring on carpels of *Populus alba* and *P. tremula* as a new species, *Taphrina rhizophora.* He gave dimensions of the asci as 80-156μ × 16-22μ, and described the deep insertion of the asci and their long, rhizoidal, often forked, basal extensions. (He suggested that the fungus known in North America on *P. tremuloides* was the same.) Sadebeck (1890) in recognizing *T. rhizophora,* separated the form on *P. tremula* as a new species, *Taphrina johansonii.* He gave the ascus-length of *T. rhizophora* as 120-160μ, showing no overlapping with *T. johansonii,* and these measurements have been copied in subsequent literature. Actually there is an overlapping, the writer's measurements (above) showing asci of *T. rhizophora* as short as 76μ.

The writer's stay in Sweden in 1939 was interrupted before a visit to Uppsala could be made, and Johanson's type material has not been studied. This does not seem important since the larger size of the asci on *P. alba* is quite apparent.

Following the principle of disturbing existing situations as little as possible both *T. rhizophora* and *T. johansonii* are here recognized as valid species, though it is not clear that they are well distinguished. Branching rhizoidal extensions of the asci are as common in the one fungus as in the other, and there is an overlapping in ascus-size between the two. Consistent treatment of species on *Populus* would call for uniting these two species into one, or for division of *Taphrina populina* into several species.

The occurrence of *T. rhizophora* on *P. tremula* reported by the writer (1936a) was an error, due to failure to recognize that Sadebeck meant to separate the fungus on *P. tremula* as *T. johansonii.* Jaczewski (1926) reports *T. rhizophora* as occurring on *Populus bachofeni.* This host, according to Index Kewensis, is identical with *P. alba.*

HOST INDEX TO SPECIES OF *TAPHRINA* ON SALICACEAE

Populus alba L.
Taphrina rhizophora Johans.
Populus angulata Ait.
Taphrina populina Fr.
Populus balsamifera L.
Taphrina populina Fr.
Populus berolinensis L.
Taphrina populina Fr.
Populus canescens Reichenb.
Taphrina johansonii Sadeb.
Populus ciliata Wallr.
Taphrina populina Fr.
Populus fremontii S. Wats.
Taphrina populi-salicis Mix
Populus generosa Henry
Taphrina populina Fr.
Populus grandidenta Wats.
Taphrina johansonii Sadeb.
Populus laurifolia Ledeb.
Taphrina populina Fr.
Populus nigra L.
Taphrina populina Fr.
Populus nigra L. var. *italica* Dur.
Taphrina populina Fr.
Populus petrowskyana Schneid.
Taphrina populina Fr.
Populus rasomowskyana Schneid.
Taphrina populina Fr.
Populus sieboldii Miq.
Taphrina johansonii Sadeb.
Populus tremula L.
Taphrina johansonii Sadeb.
Populus tremula L. var. *pendula* Loud.
Taphrina johansonii Sadeb.
Populus tremula L. var. *villosa* Wesm.
Taphrina johansonii Sadeb.
Populus tremuloides Michx.
Taphrina johansonii Sadeb.
Populus trichocarpa Torr. and Gray
Taphrina populi-salicis Mix
Salix laevigata Bebb
Taphrina populi-salicis Mix

III. SPECIES ON BETULACEAE

Corylus, Ostrya, Carpinus, Betula, Alnus

29. *Taphrina coryli* Nishida

Taphrina coryli Nishida, Miyabe Festschrift, Tokyo, 1911, pp. 157-212.

Causing leaf curl involving small spots, large areas, or the whole blade, of *Corylus americana* Marsh., *C. heterophylla* Fisch., *C. rostrata* Ait., and *C. sieboldiana* Blume. Affected areas at first yellowish, becoming white at maturity of asci.

Mycelium intercellular.

Asci amphigenous, cylindric or cylindric-clavate, rounded or truncate at the apex, seated on or slightly inserted in a stalk cell which may be a little broader than the ascus. Ascospores eight, globose, ovate, or elliptic, often budding in the ascus. (Fig. 12, B.)

Dimensions: Of *asci*, 20-40μ × 8-12μ; of *stalk cells*, 10-20μ × 8-17μ; of *spores*, 4-6.5μ × 3.5-6μ.

Distribution: eastern North America, Japan.

Material examined: Corylus americana. Connecticut: Sandy Hook, Botsford Hill, July 4, 1928, A. J. M.; Hammertown Road, between Botsford and Monroe, July 20, 1947, *id.* Massachusetts: Andover, Harold Parker Forest, June 3, 1939, D. H. Linder. Wisconsin: Madison, June 2, 1915, J. J. Davis (F. Columb. 4882); Sparta, June, 1916, J. J. Davis.

C. heterophylla. Japan: Iwate, Terada, June 8, 1907, K. Sawada (Herb. Morioka Imp. Coll. Agric. and For.).

C. rostrata. Connecticut: Westville, summer 1890, R. Thaxter (Rel. Farl. 642).

C. sieboldiana. Japan: Iwate, Mt. Himekawe, June 30, 1907, K. Sawada (Herb. Morioka Imp. Coll. Agric. and For.).

30. *Taphrina ostryae* Massalongo

Taphrina ostryae Massalongo, Bot. Centbl. 34:389-390. 1888.

Causing small, brown, definitely margined, unthickened spots on leaves of *Ostrya carpinifolia* Scop.

Mycelium subcuticular.

Asci hypophyllous, oblong, rounded or obtuse at the apex, seated on a stalk cell which may be somewhat wider than the ascus. Ascospores eight, globose. (Fig. 13, A.)

Dimensions: Of *asci,* 20-24μ × 12-14μ (Massalongo), 17-26μ × 7-10μ (Mix); of *stalk cells,* variable size (Massalongo), 7-10μ × 7-13μ (Mix); of *spores,* 4.5-5μ × 4-4.5μ.

Distribution: Italy.

Material examined: ITALY: Lucca, Vellana, Oct., 1890, G. Tognini (Br. and Cav. F. Par. D. Pl. Colt. od Ut. 169); Verona, valley Tregagno, July, 1898, C. Massalongo (loc. class.).

31. *Taphrina virginica* Sadebeck

Taphrina virginica Sadebeck, Ber. Deutsch. Bot. Ges. **13**:265-280. 1895.

Causing small, pale yellowish thickened areas or leaf curl of the whole blade, on leaves of *Ostrya virginica* Willd.

Mycelium intercellular.

Asci epiphyllous, sometimes hypophyllous, rounded or truncate at the apex, with rounded or truncate, sometimes broadened base, lacking a stalk cell. Ascospores eight, ovate to elliptic, often budding in the ascus. (Fig. 13, B.)

Dimensions: Of *asci,* 20-46μ × 8-13μ, the widened base occasionally measuring 17μ; of *spores,* 4-6.5μ × 4-5μ.

Distribution: eastern North America.

Material examined: KANSAS: Vinland, Baldwin Woods, May 15, 1947, A. J. M.; Lecompton, May 15, 1947, R. L. McGregor. MASSACHUSETTS: Princeton, July, 1888, W. G. Farlow; Wellesley, June 8, 1888, A. B. Seymour (E. F. 497a. Duplicate of type). NEW HAMPSHIRE: Temple, June 16 and 18, 1888, A. B. and A. C. Seymour (E. F. 497b, and 497c). VERMONT: Ferrisburg, Shellhouse Mtn., July 23, 1884, Faxon. WISCONSIN: Potosi, June 7, 1918, J. J. Davis. ONTARIO: Woods east of Holland River, June 3, 1937, H. S. Jackson (Crypt. Herb. Univ. Toronto, 12066).

32. *Taphrina carpini* (Rostr.) Johanson

Taphrina carpini (Rostr.) Johanson, Ofv. Kongl. Svensk. Vetensk. Akad. Forhandl. **1885**:29-47. 1886.
Exoascus carpini Rostrup, Bot. Centbl. **5**:153-154. 1886.

Causing witches' brooms of *Carpinus betulus* L. and *C. orientalis* Mill.

Mycelium subcuticular.

Asci hypophyllous, cylindric, rounded at the apex, truncate and sometimes broadened at the base, lacking a stalk cell; ascospores eight, ovate to elliptic. (Fig. 13, C.)

Dimensions: Of *asci,* 20-30μ × 7-14μ (may broaden at base to 20-24μ); of *spores,* 3.5-5μ × 3-4.5μ.

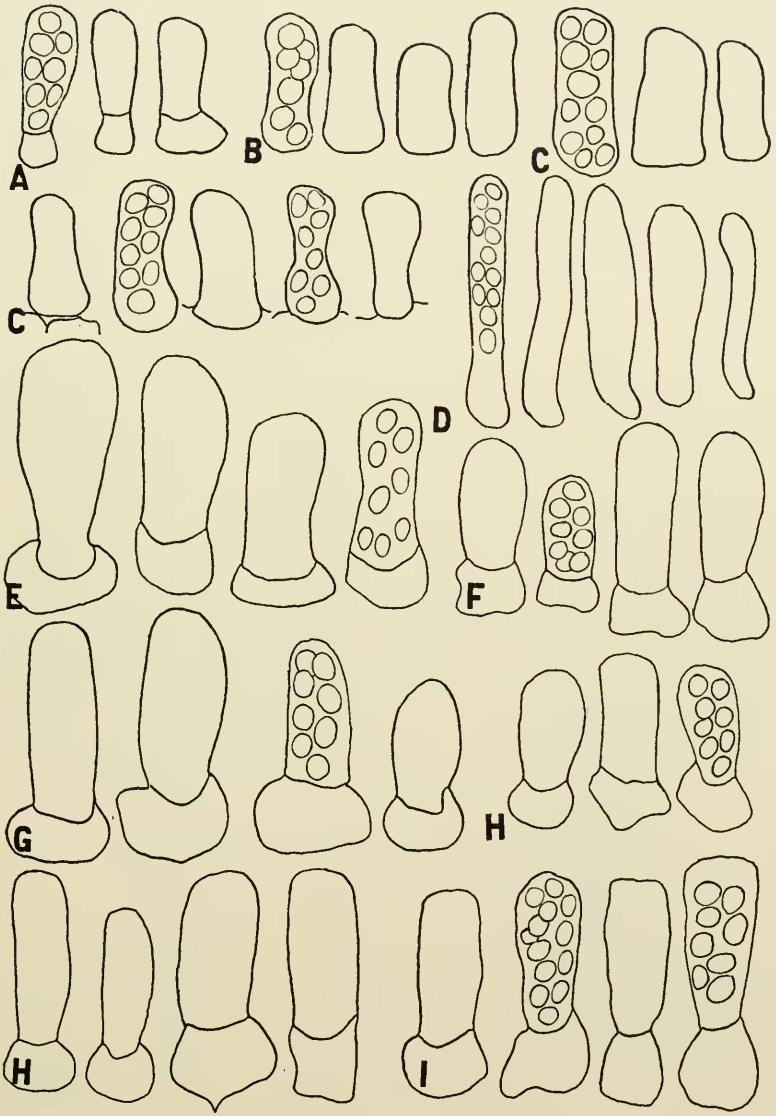

Fig. 13. Asci (× 900) of A, *Taphrina ostryae;* B, *T. virginica;* C, *T. carpini;* D, *T. australis;* E, *T. betulicola;* F-I, *T. americana;* F, G, on *Betula fontinalis;* H, on *B. papyrifera;* I, on *B. lutea.*

Material examined: Carpinus betulus. ENGLAND: Surrey, Virginia Water, July 22, 1935, A. J. M. GERMANY: Thuringia, Steiger near Erfurt, May 29, 1920, H. Diedicke; Escheberg near Bergsdorf, June 20, 1909, O. Jaap (F. Sel. Exs. 408).

C. orientalis. RUSSIA: Kubinski, Ascobaidjan, May 30, 1927; Uljanishtshev (Herb. Inst. Prot. Plants, Sect. Phytopath., Leningrad). SWEDEN: Lund, June 11, 1887, E. Ljungström (Fungi Suecici).

33. *Taphrina australis* (Atk.) Geisenhagen

Taphrina australis (Atk.) Giesenhagen, Flora **81**:267-361. 1895.
Exoascus australis Atkinson, Bull. Torr. Bot. Club **21**:372-380. 1894.

Causing leaf-curl (without evident thickening) of small areas or of the whole blade of leaves of *Carpinus caroliniana* Walt.

Mycelium subcuticular.

Asci epiphyllous, cylindric, truncate or rounded at the apex, narrowed or somewhat broadened at the base, lacking a stalk cell. Ascospores eight, ovate to elliptic. (Fig. 13, D.)

Dimensions: Of *asci,* 20-53μ × 7-12μ (asci as long as 60μ reported by Atkinson); of *spores,* 4-6μ × 2.5-4.5μ.

Distribution: eastern North America.

Material examined: ALABAMA: Auburn, April 30, 1892, G. F. Atkinson (Type? Herb. Dept. Plant Path. Cornell Univ. Atkinson Coll. 2401). CONNECTICUT: North Bloomfield, May, 1919, P. Spaulding (Herb. U. S. D. A. Div. For. Path. 45975).

This species seems to be well distinguished from the preceding by its larger asci and by not forming witches' brooms.

34. *Taphrina betulicola* Nishida

Taphrina betulicola Nishida, Miyabe Festschrift. Tokyo. 1911.

Causing witches' brooms on *Betula ermani* Cham.

Mycelium subcuticular, perennial.

Asci cylindric, rounded or truncate at the apex, provided with a cylindric stalk cell. Ascospores eight, ovate to elliptic, frequently budding in the ascus. (Fig. 13, E.)

Dimensions: Of *asci,* 26-46μ × 13-22μ; of *stalk cells,* 7-13μ × 13-20μ; of *spores,* 3.5μ × 3μ. (Nishida's measurements of stalk cells were: 8-20μ × 20-26μ.)

Distribution: Japan.

Material examined: *Betula ermani.* JAPAN: Nikko, Mt. Shirane, July, 1907, S. Kusano. (Apparently part of type collection. Received from Kusano).

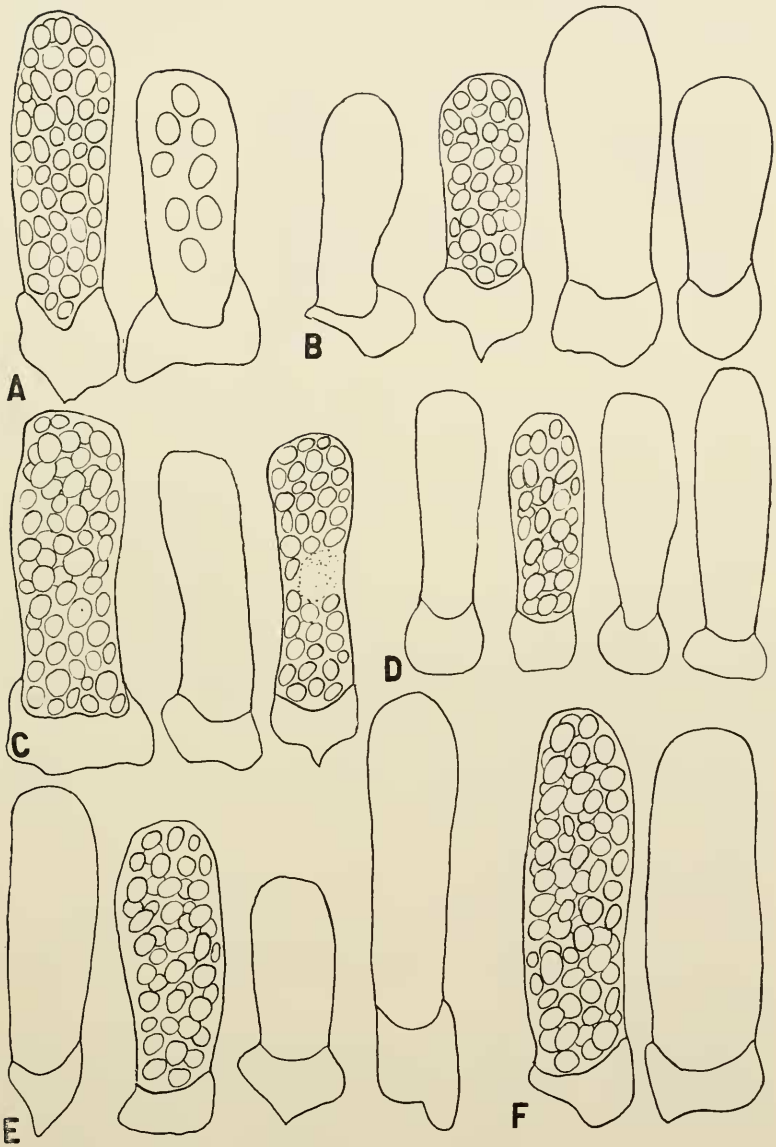

Fig. 14. A-E, asci of *Taphrina betulina*. A, on *Betula carpatica*; B, *B. intermedia*; C, *B. pubescens*; D, *B. pubescens* (as *T. lagerheimii*); E, *B. pubescens* (as *T. lapponica*); F, asci of *T. splendens*. All × 900.

This species is, for the present, held to be distinct from *T. betulina*. Though its ascus-dimensions fall within the size-range of that species, the average size (35 × 16μ) is less, and the stalk cell is shorter.

35. *Taphrina betulina* Rostrup

Taphrina betulina Rostrup, Tidsskr. f. Skovbrug. **6**:199-300. 1883.
Exoascus betulinus (Rostr.) Sadebeck, Jahrb. Hamburg. Wissensch. Anst. **10**:5-110. 1893.
Taphrina lagerheimii Palm, Arkiv. Bot. **15**:1-41. 1917.
Taphrina lapponica Juel, Svensk. Bot. Tidsskr. **6**:353-372. 1912.
Exoascus lapponicus (Juel) Jaczewski, Pocket Key for determination of fungi. Part I. Exoascales, Leningrad, 1926.
Taphrina turgida (Sadeb.) Giesenhagen, Flora **81**:267-361. 1895.
Exoascus turgidus Sadebeck, Jahrb. Hamburg. Wissensch. Anst. **1**:93-124. 1884.
Taphrina willeana Svendsen, Nyt Mag. Vidensk. **40**:363-368. 1902.

Causing witches' brooms. In early stages several or all of the leaves of a shoot may be yellowed (sometimes slightly enlarged but not thickened), but the adventitious twigs of a typical broom may not be present. Subsequently a witches' broom develops. Occurring on: *Betula aurata* Bechst., *B. carpatica* Waldst., *B. intermedia* Thomas, *B. nana* L., *B. pendula* Roth., *B. pubescens* Ehrh.

Mycelium subcuticular, perennial.

Asci cylindric, rounded or truncate at the apex, provided with a stalk cell which may be broad and seated, or wedge shaped and inserted between epidermal cells. Ascopores eight, ovate to elliptic, frequently budding in the ascus, filling it with smaller, ovate or elliptic blastopores. (Fig. 14, A-E, Fig. 15, A, B.)

Dimensions: Of *asci*, 23-73μ × 10-26μ; of *stalk cells*, 7-27μ × 10-30μ; of *ascospores*, 4.5-6.5μ × 4-5.5μ; of *blastospores*, 3.5-6μ × 2-4.5μ.

Distribution: Europe.

Material examined: Betula aurata. GERMANY: Hamburg, Eppendorfer Moor, June 19, 1906, O. Jaap (F. Sel. Exs. 352).

B. carpatica. GERMANY: Scheibe near Schandau, June, 1909, W. Krieger (F. Sax. 2054).

B. intermedia. NORWAY: Gran Hadeland, top of Mt. Framstadsaeterfjeld, June 18, 1901, N. Wille (type of *T. willeana* Svends., received from I. Jørstad). SWEDEN: Jämtland, Storlien, Aug. 24, 1939, A. J. M. (two collections); Lappland, Abisko, Aug. 17-21, 1939, A. J. M. (ten collections); Pålnoviken, Aug. 20, 1939, A. J. M.; Kaskajaure, July 15, 1938, Th. Arwidsson (as *T. lapponica*).

B. nana. NORWAY: Finnmark, Bossekop in Alta, July 29, 1924, I. Jørstad.

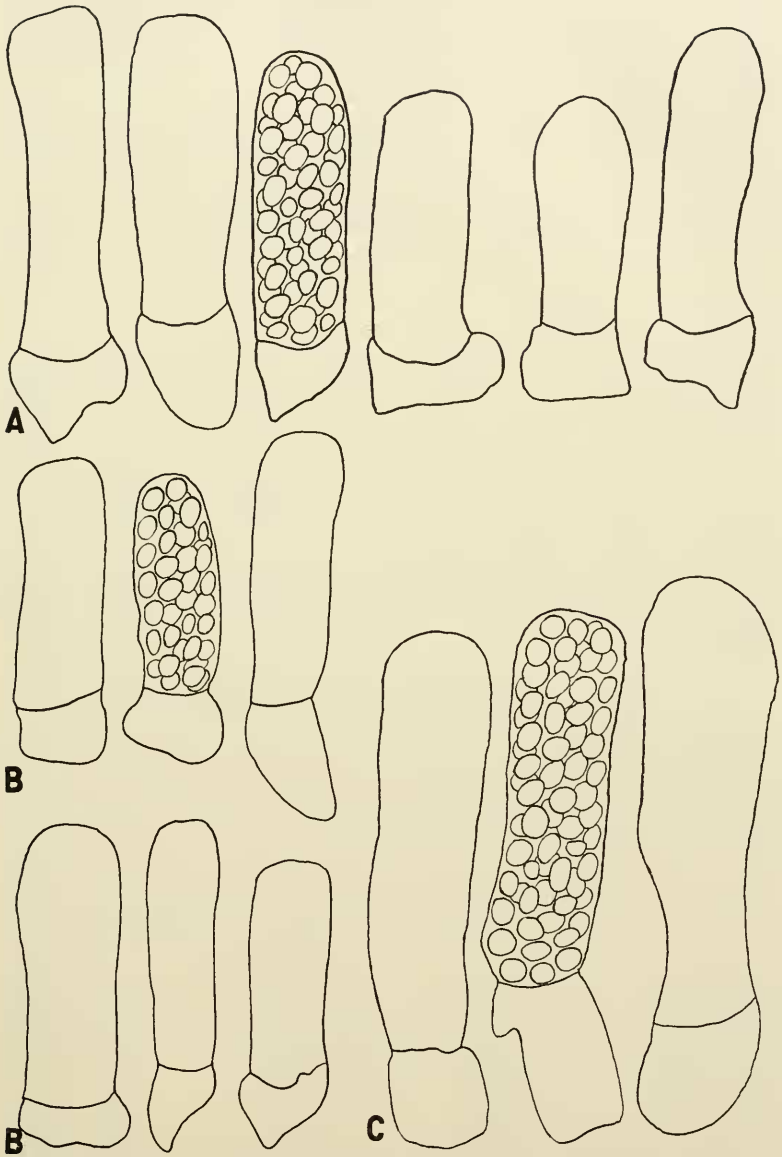

FIG. 15. A, B, asci of *Taphrina betulina;* A, on *B. pendula* (*T. turgida*); B, *B. intermedia* (*T. willeana*); C, asci of *T. splendens* on *B. pubescens.* All × 900.

B. pendula (as *T. turgida*). GERMANY: Brandenburg, Bredower Forest near Nauen, June, 1904, H. Sydow (Myc. Germ. 249). SWEDEN: Grisslehamn, July 13, 1912, O. Juel; Stockholm, Haga, June 12, 1910, B. Palm, Norra Djurgården, June 30, 1939, A. J. M.; Tungelsta, July 13, 1939, A. J. M.

B. pubescens. GERMANY: Westphalia, Hauberg near Siegen, May 22, 1920, H. Ludwig (Myc. Germ. 1646). IRELAND: County Wicklow, Killadreenan House, June 23, 1935, A. J. M. SWEDEN: Jämtland, July 13, 1931, A. G. Eliasson; Storlien, Skurdalshöjden, July 15, 1936, T. Arwidsson; Storlien, Aug. 24, 1939, A. J. M. (two collections); Kälarna, B. Palm; Quikjokk, 1887, G. Lagerheim (Roum. F. G. 4561).

B. pubescens (as *T. lapponica*). NORWAY: Troms, Kirkenesmoen in Målselv, July 31, 1926, I. Jørstad. SWEDEN: Härjedalen, Fjällnäs, Malmagsvålen, June 28, 1933, A. G. Eliasson; *ibid.*, July 2, 1933, A. G. E.; Jämtland, Frostviken, Jorniklumpen, July 2, 1934, J. A. Nannfeldt (F. Exs. Suec. 651); Lappland, Björkliden, July 19, 1911, O. Juel (type); Abisko, July, 1907, T. Vestergren (Micr. Rar. Sel. 1620. *"Vidit auctor"*).

B. pubescens (as *T. lagerheimii*). SWEDEN: Lappland, Abisko, Vaggejokk, Vilkisorta, Björkliden, Pålnoviken, B. Palm (several undated collections).

Synonymy: a. Taphrina turgida (Sadeb.) Gies.

Rostrup (1883) described *Taphrina betulina* from "birch" without giving the specific name of the host, though later (1890) he stated that it was *Betula odorata* (*B. pubescens*). Sadebeck (1884) described *Exoascus turgidus*, also from "birch," and gave *Taphrina betulina* as a synonym. Later Sadebeck (1893) reported the host for *T. turgida* as *B. verrucosa* (*B. pendula*), and stated that *T. betulina* occurred on *B. pubescens*. Sadebeck's distinction between the two species was based on the form of the stalk cell, *T. betulina* having a broad stalk cell, truncate or rounded at the base, seated on the epidermis, while *T. turgida* had a wedge shaped stalk cell, pointed below, and inserted between the epidermal cells. (He also stated that the two species differed in the manner of formation of their ascogenous cells.)

Rostrup (1890) expressed the opinion that *Taphrina betulina* and *T. turgida* were identical, but later (1896) he agreed with Sadebeck's distinction between the stalk cells of the two forms. He also suggested a biological distinction, since he had observed *Betula*

pubescens and *B. pendula* growing close together, with only the former showing witches' brooms.

Actually there is no morphological distinction between the fungus on *Betula pubescens* and the one on *B. pendula*, either in size and shape of asci or in form of stalk cells. In all specimens examined from the hosts named above, both the broad, flat type of stalk cell, and the wedge-shaped, inserted one have been seen. Sadebeck himself (1893) stated that the stalk cells of *T. turgida* were very variable, and that it would be difficult to tell the two species apart by means of this character.

b. Taphrina lapponica Juel.

Juel (l. c.) in distinguishing *T. lapponica* from *T. betulina* stated that the former did not form witches' brooms though invading "whole shoots." According to his account all of the leaves on a branch became yellowed and sometimes enlarged, but adventitious buds were not formed. In the summer of 1939, during a stay in Lappland and Jämtland, the writer become convinced that the above-described appearance is that of a young stage of a witches' broom, resulting from infections of the current year or of a recent year. Stages intermediate between "whole-shoot infection" and witches' brooms were common.

Juel did not find any marked difference in ascus-size between the two species, but reported ascus-dimensions for *T. lapponica* as 40μ × 16μ, the dimensions for *T. betulina* being 45-55μ × 15-20μ. He did, however, assign a shorter host list, finding *T. lapponica* to occur on *Betula intermedia* and on *B. pubescens*.

That the two forms cannot be distinguished morphologically may be seen from the following tabulation made mostly from specimens collected by the writer in Sweden in 1939.

Taphrina lapponica, not forming witches' brooms.

Ascus-size in microns	Stalk cell-size in microns	Collection No.	Host
45-50 × 17-23	8-10 × 17-23	T691	*B. intermedia*
30-50 × 13-20	8-13 × 17-26	T670	*B. intermedia*
40-73 × 17-20	8-17 × 20-23	T672	*B. intermedia*
23-50 × 13-20	8-10 × 20-26	T673	*B. intermedia*
30-50 × 13-17	7-17 × 13-26	T676	*B. intermedia*
33-66 × 13-18	10-13 × 17-20	T677	*B. intermedia*
36-50 × 13-20	7-13 × 17-26	T678	*B. intermedia*
36-50 × 13-20	7-10 × 17-23	T680	*B. intermedia*
36-60 × 17-20	7-10 × 17-23	T681	*B. intermedia*
33-66 × 13-20	7-10 × 17-23	T683	*B. intermedia*
30-46 × 12-20	7- 8 × 13-23	T685	*B. intermedia*
26-43 × 17-20	7-13 × 17-20	T687	*B. intermedia*
33-50 × 13-20	7-13 × 17-20	T766	*B. intermedia*

Ascus-size in microns	Stalk cell-size in microns	Collection No.	Host
40-60 × 13-20	8-10 × 17-20	T690	*B. pubescens*
33-53 × 13-20	7-17 × 13-20	T692	*B. pubescens*
46-56 × 15-26	10-23 × 17-30	T643	*B. pubescens*
50-60 × 15-26	10-17 × 17-26	T635	*B. pubescens*
43-56 × 13-15	8-10 × 17-20	T620	*B. pubescens*
33-40 × 15-23	8-10 × 20-27	T619	*B. pubescens*
33-50 × 12-17	10-13 × 17-23	T618	*B. pubescens*
33-46 × 13-20	8-10 × 17-23	T480	*B. pubescens*
36-50 × 12-18	8-17 × 13-23	T335	*B. pubescens*

T. betulina, forming typical witches' brooms.

Ascus-size in microns	Stalk cell-size in microns	Collection No.	Host
40-53 × 13-20	8-17 × 17-23	T566	*B. aurata*
40-63 × 13-23	8-13 × 17-23	T567	*B. carpatica*
30-53 × 13-20	8-13 × 20-26	T668	*B. intermedia*
30-50 × 13-20	8-13 × 17-23	T671	*B. intermedia*
34-46 × 15-21	6-15 × 15-23	T80	*B. pubescens*
43-63 × 10-17	8-23 × 13-20	T565	*B. pubescens*
33-50 × 10-20	8-13 × 13-23	T649	*B. pubescens*
43-56 × 17-26	13-23 × 10-26	T656	*B. pubescens*
36-46 × 13-23	10-27 × 13-27	T168	*B. pubescens*

This would give as dimensions for *T. lapponica: Asci,* 23-73μ × 12-23μ.; *stalk cells,* 7-33μ × 13-27μ.; for *T. betulina: Asci,* 30-63μ × 10-26μ.; *stalk cells,* 7-27μ × 10-27μ.

The writer's collections of *T. lapponica* on *B. intermedia* and *B. pubescens* were made from trees bearing typical witches' brooms of *T. betulina* as well as from adjacent trees showing only "shoot-infections." This was in the exact locality in which Juel had collected his fungus. It was apparent that the *lapponica*-infections, which included cases where one or a few leaves of a shoot were diseased, were juvenile stages of witches' brooms. A witches' broom being a perennial structure, and only identifiable as a witches' broom after adventitious buds have developed twigs, it could only become established through such juvenile stages. One or more leaves must become infected, mycelium invade the whole shoot, and the formation and development of adventitious buds be induced. In localities such as Lappland, where infestation is great and where infection seems to occur every year, juvenile stages are abundant.

Complete proof of this idea of the formation of a witches' broom could be furnished by inoculation-experiments, which have not yet been possible.

c. Taphrina lagerheimii Palm

This fungus was described by Palm as affecting its host (*B. pubescens*) in the same manner as *T. lapponica* but having *asci,* 53-60μ × 13-5-17μ.; and *stalk cells,* 19.5-23.5μ × 19.5-5-26μ.

Palm preserved no type specimens of his various new species of *Taphrina*. The specimens (listed above) studied by the writer were found by Dr. Th. Arwidsson among Lagerheim's collections in Stockholm's Högskola. They had been collected by Palm and evidently studied by him but bore no date. No collections from Kapellskär in Uppland was found, that being Palm's type locality for *T. lagerheimii*.

Study of these specimens showed dimensions to be: *Asci*, 33-60μ × 10-18μ; *stalk cells*, 10-17μ × 23μ. The stalk cells seen were shorter and narrower than those reported by Palm but even his dimensions fall within the limits for *T. betulina* (including *T. lapponica* and *T. turgida*): *Asci*, 23-73μ × 10-26μ; *stalk cells*, 7-27μ × 10-27μ. Clearly *T. lagerheimii* can not be distinguished from *T. lapponica* and it must become synonymous with *T. betulina*.

d. Taphrina willeana Svendsen

This fungus, described by Svendsen as affecting leaves (wholly or in part) but not discoloring or thickening them, and not forming witches' brooms, is obviously like *T. lapponica*. Svendsen reported its dimensions as: *Asci*, 40-50μ × 15-20μ; *stalk cells*, 20-24μ × 24-30μ. Dimensions obtained by the writer from a study of Svendsen's type-specimen are: *Asci*, 33-56μ × 13-17μ; *stalk cells*, 10-24μ × 13-24μ. These dimensions do not distinguish *Taphrina willeana* from *T. betulina* nor from Juel's *T. lapponica*, nor has it any other distinguishing feature. It must be included in *Taphrina betulina*.

Lind (1913) reports the collection by Rostrup of *Taphrina betulina* on *Betula pubescens* Ehrh. var. *urticifolia* (Loud.) Schelle, and on *B. nigra* L. These specimens have not been seen by the writer.

36. *Taphrina splendens* Palm

Taphrina splendens Palm, Arkiv. Bot. **15**:1-41. 1917.

Affecting leaves of *Betula pubescens* Ehrh. Leaves (in specimens seen) deeper green than normal above, rusty tan beneath, not thickened or enlarged. Apparently not forming witches' brooms.

Mycelium subcuticular.

Asci hypophyllous, cylindric, rounded at the apex; stalk cell rounded or truncate below, of nearly the same width as the ascus. Ascospores, eight, ovate to elliptic, frequently budding in the ascus. (Fig. 14, F, Fig. 15, C.)

Dimensions: Of *asci*, 50-96μ × 13-23μ; of *stalk cells*, 10-33μ × 10-26μ; of *spores*, 4-6.5μ × 3-5.5μ.

Distribution: Northern Norway, Swedish Lappland.

Material examined: NORWAY: Nordland, Bjellådalen in Nord Rana, Juy 21, 1926, I. Jørstad. SWEDEN: Lappland, Abisko, B. Palm (presumably the type, though not so designated); Luleå, July 12, 1926, J. Vleugel.

Some doubt is felt whether to regard this fungus as a separate species or to consider it a northern variant of *Taphrina betulina*. It is possible that it may, on further study, be found to cause witches' brooms. Its asci are definitely larger than those of *T. betulina*.

The longest asci observed in Palm's specimen measured 80μ. Longer asci (96μ) were found in Jørstad's collection. If *Taphrina splendens* is to be recognized as a separate species it should include all northern forms with large asci.

37. *Taphrina nana* Johanson

Taphrina nana Johanson, Ofvers. of K. Svensk. Vetensk. Akad. Forhandl. **1885**:29-47. 1886.
Exoascus nanus (Johans.) Sadebeck, Jahrb. Hamburg. Wissensch. Anst. **10**:5-110. 1893.
Taphrina alpina Johanson, Bih. K. Svensk. Vetensk. Akad. Handl. **13**:3-28. 1887.
Exoascus alpinus (Johans.) Sadebeck, Jahrb. Hamburg. Wissensch. Anst. **10**:5-110. 1893.

Causing yellowing of leaves, without enlargement or thickening, affecting part or all of a shoot, or inducing definite witches' brooms on *Betula ermani* Cham., *B. intermedia* Thom., *B. japonica* Sieb., *B. nana* L., *B. pendula* Roth., *B. pubescens* Ehrh.

Mycelium intercellular (subcuticular in early stages).

Asci at first hypophyllous, later amphigenous, cylindric, rounded or truncate at the apex, with a broad stalk cell seated on the epidermis or with a narrower, wedge-shaped stalk cell inserted between epidermal cells. Ascospores eight, round, ovate or elliptic, often budding in the ascus. (Fig. 16, A-C.)

Dimensions: Of *asci*, 13-30μ × 8-15μ; of *stalk cells*, 7-16μ × 8-20μ; of *ascospores*, 3.5-6μ × 3.5-5μ.

Distribution: Sweden, Germany, Russia, Kamchatka.

Material examined: B. nana. NORWAY: Sør Trøndelag, Knutshø in Opdal, July, 1887, A. Blytt. SWEDEN: Jämtland, Areskutan, July 12, 1884, C. J. Johanson (F. Par. Scand. Exs. 231b. Labelled "*T. carnea*" but apparently duplicate of type); *ibid.*, July 16, 1885, C. J. Johanson (Herb. Bot. Mus. Stockholm 3649); between Hallen and Bydalen, Aug. 3, 1909, O. Juel; Härjedalen, Glän, G. Lager-

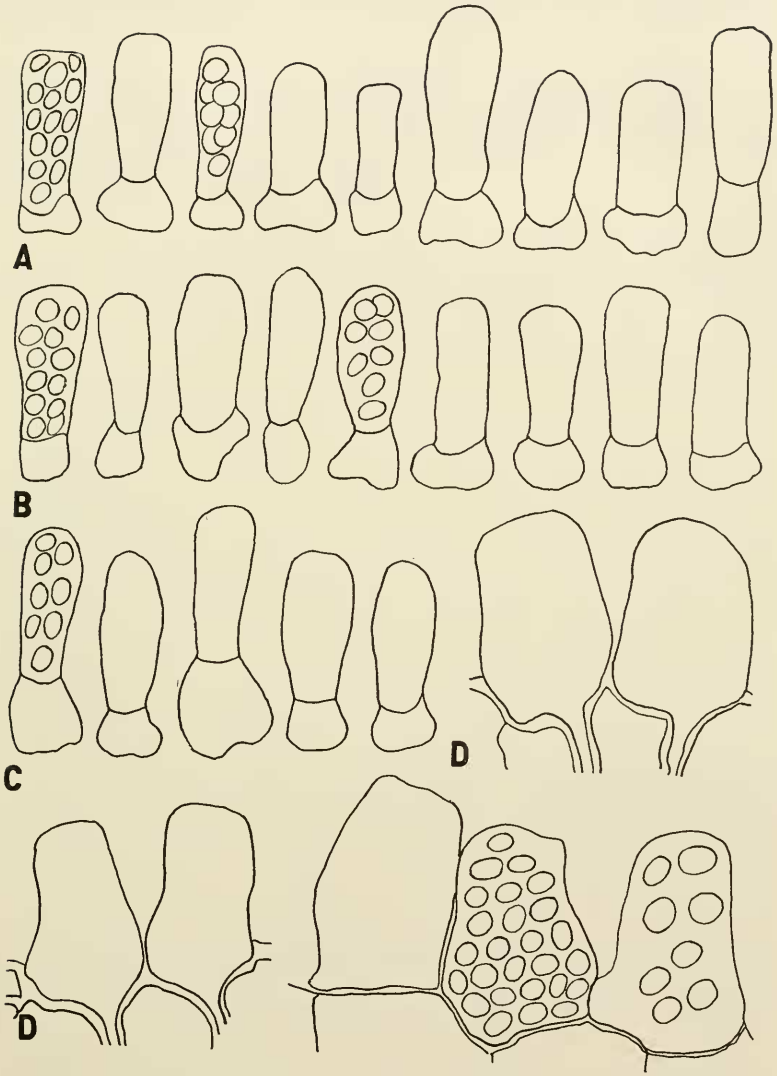

Fig. 16. A-C, asci of *Taphrina nana*. A, on *Betula nana;* B, on *B. nana* (as *T. alpina*); C, on *B. pubescens*. D, asci of *Taphrina boycei* on *Betula fontinalis*. All × 900.

heim; Lappland, Abisko, July 28, 1911, O. Juel (three collections, two labelled "*T. alpina*" the other "*T. nana* var. *hyperborea*" Juel); *ibid.*, B. Palm; *ibid.*, Aug. 18-21, 1939, A. J. M. (four collections, three identifiable as *T. alpina*, one as *T. nana*).

B. pendula. GERMANY: Westphalia, vicinity of Siegen, May-June, 1920, A. Ludwig (Myc. Germ. 1649, as *T. turgida*). POLAND: Anin, July, 1938, H. Juraskowna (Herb. Inst. Phytopath. Schol. Sup. Agric. Varsaviensis, as *T. turgida*). SWEDEN: Falun, July 6, 1904 (as *T. alpina*).

B. pubescens. SWEDEN: Lappland, Abisko, B. Palm.

The distinction between *Taphrina nana* and *T. alpina*, made by Johanson (1887) and concurred in by Juel (1909) was that *T. nana* forms intercellular mycelium throughout the leaf parenchyma, while *T. alpina* has subcuticular mycelium. The occurrence of intermediate forms makes this distinction untenable. Specimens identified by Johanson and by Juel as *T. alpina* show subcuticular mycelium, but modification of one or two rows of the spongy parenchyma as well as of the epidermis occurs. The asci in these specimens are hypophyllous. A specimen collected by Juel in Jämtland, Aug. 3, 1909, and identified by him as *T. nana*, and a specimen collected at Abisko by the writer Aug. 19, 1939, show modification of the lower half of the spongy parenchyma, a little intercellular mycelium, and hypophyllous asci intermediate in size (asci 17-26μ × 8-10μ, stalk cells 7-10μ × 8-13) between those of *T. alpina* and *T. nana* (Johanson's measurements). In most specimens of *T. nana* the mycelium extends throughout the leaf, all the leaf tissues are modified, and the asci are amphigenous, being slightly larger when occurring on the upper surface of the leaf. The asci of *Taphrina alpina* are described by Johanson as 20-27μ × 9-14μ, with stalk cells 8-14 (18)μ × 12-20μ; the asci of *T. nana* being 18-30μ × 7-9μ, stalk cells 7-15μ × 7-17μ. Actually there is no size-distinction between the two forms, though the hypophyllous asci (of either form) are somewhat smaller than the epiphyllous asci.

It is evident that *Taphrina alpina* is merely a juvenile stage of *Taphrina nana*. Infection apparently occurs through the lower epidermis, the spongy parenchyma is first invaded and larger asci form on the upper epidermis. Since the two species are indubitably synonymous the name *Taphrina nana* Johanson has priority. It is interesting that in *Taphrina nana* as in *T. betulina* early stages can be found in which one or all of the leaves of a shoot are attacked but no witches' brooms have yet been formed.

The occurrence in Kamchatka of *T. alpina* on *Betula ermani,* and of *T. nana* on *B. japonica* are reported by Jaczewski (1926). Specimens were not obtainable.

38. *Taphrina americana* Mix

Taphrina americana Mix, Trans. Kansas Acad. Sci. **50**:77-83. 1947.

Causing witches' brooms on *Betula fontinalis* Sarg., *B. lutea* Michx., and *B. papyrifera* Marsh.

Mycelium subcuticular, perennial.

Asci hypophyllous, cylindric, rounded or truncate at the apex; stalk cell broader than the ascus, short and rounded, truncate at the base; ascospores eight, often budding in the ascus. (Fig. 13, G-J.)

Dimensions: Of *asci,* 17-40μ × 8-18μ; of *stalk cells,* 6-20μ × 7-23μ; of *spores,* 4-6μ × 3.5-5.5μ.

Distribution: North America (occasional).

Material examined: B. fontinalis. Colorado: Larimer Co., tributaries South Fork Cache Le Poudre River, Happy Hollow, July 2, 1896, L. H. Pammel (Herb. Iowa Agric. Coll. Plants N. Colo. 118); Boulder Canyon, El Vado, July 27, 1942, A. J. M. (Type).

B. lutea. New Hampshire: Mt. Washington, Alpine Garden, R. Thaxter (Type).

B. papyrifera. New Hampshire: Mt. Washington, Alpine Garden, July, 1886, R. Thaxter (Type). Wisconsin: Solon Springs, July 20, 1914, J. J. Davis.

This fungus is considered distinct from both *Taphrina betulina* and *T. nana* because it is intermediate in ascus-size between these two fungi. It further differs from them in host range and geograpic distribution.

39. *Taphrina boycei* Mix

Taphrina boycei Mix, Amer. Jour. Bot. **26**:44-48. 1939.

Causing small unthickened spots, pale yellow on both sides (resembling those caused by *T. flava*) on leaves of *Betula fontinalis* Sarg., and *B. occidentalis* [6] Hook.

Mycelium intercellular.

Asci hypophyllous, oblong to broad-cylindric, rounded at the apex, often broadened at the base, arising directly from intercellular mycelium, containing persistent pale yellow oil globules; ascospores eight, round, ovate or elliptic. (Fig. 16, D.)

6. Rehder assigns this species in part to *Betula fontinalis* Sarg. and in part to *B. papyrifera* Marsh. var. *occidentalis* (Hook) Sarg. Perhaps the form in question belongs to the latter.

Dimensions: Of *asci,* on *B. fontinalis,* 30-60μ × 20-36μ, on *B. occidentalis,* 30-46μ × 20-33μ; of *ascospores,* 4-5μ × 3.5-4μ.

Distribution: British Columbia.

Material examined: B. fontinalis. BRITISH COLUMBIA: near Cheekye, July 19, 1931, J. S. Boyce and J. L. Mielke (Herb. J. S. B. 1938. Type).

B. occidentalis. BRITISH COLUMBIA: New Westminster, Green Timbers Forest Nursery, July, 1938, Malcolm Wilson; Revelstoke, Big Bend Highway, June 30, 1931, J. S. Boyce and J. L. Mielke (Herb. J. S. B. 1963. Type).

40. *Taphrina carnea* Johanson

Taphrina carnea Johanson, Ofvers. of K. Svensk. Vetensk. Akad. Forhandl. 1885:29-47. 1886.
Exoascus carneus (Johans.) Sadebeck, Jahrb. Hamburg. Wissensch. Anst. 10:5-110. 1893.
Taphrina janus (Thomas) Giesenhagen, Bot. Zeit. 59:115-142. 1901.
Exoascus janus Thomas, Forstl. Naturw. Zeitschr. 6:305-314. 1897.
Taphrina lata Palm, Arkiv. Bot. 15:1-41. 1917.

Causing thickened, yellowish to red, leaf-curl lesions on leaves of *Betula fruticosa* Pall., *B. glandulosa* Michx., *B. humilis* Schrank., *B. intermedia* Thom., *B. lutea* Michx., *B. nana* L., *B. papyrifera* Marsh., *B. pendula* Roth., *B. pubescens* Ehrh.

Mycelium intercellular.

Asci epiphyllous, hypophyllous or amphigenous, broad-cylindric or oblong, sometimes irregular in outline, rounded or truncate at the apex, frequently broadened toward the base, sometimes compressed at the base by adjacent asci, lacking a stalk cell. Ascospores rarely seen, asci commonly filled with blastospores which may be small and ovate to elliptic, or minute and bacterioidal. (Fig. 17, A-C, F.)

Dimensions: Of *asci,* 30-86μ × 10-26μ; widening at base to as much as 30μ; of *ascospores,* 5-6μ × 3-4.5μ; of *blastospores,* 3-6μ × 2-4μ, or if bacterioidal, 1-6μ × 1-1.5μ.

Distribution: Switzerland, Sweden, Russia, eastern North America.

Material examined: B. glandulosa. NEW HAMPSHIRE: Mt. Washington, Lake of the Clouds, July 3, 1886. [Identified by Patterson (1985) as *T. bacteriosperma.*] NEW YORK: Mt. Marcy, July, 1895, C. H. Peck. [Identified by Peck (1896) as *T. bacteriosperma.*]

B. humilis. POLAND: Janow near Lwow, May 30, 1910, M. Raciborski (Myc. Polon. 51).

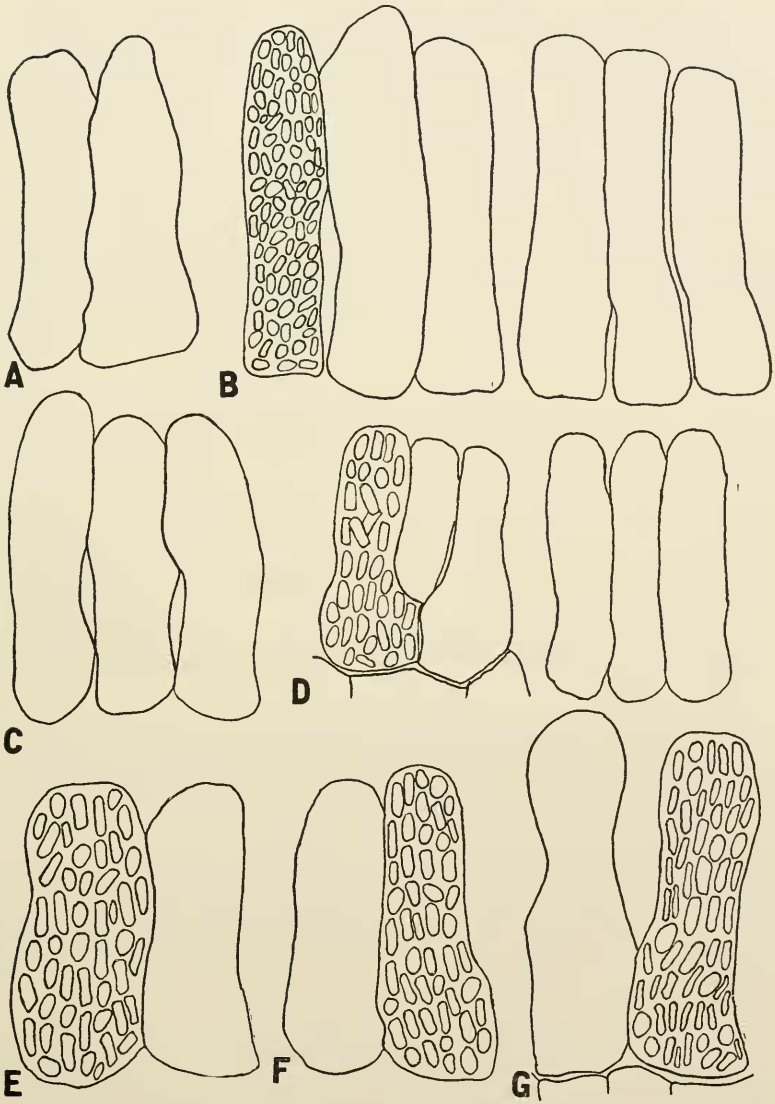

Fig. 17. Asci (× 900) of: A, *Taphrina carnea* on *Betula lutea;* B, *B. pubescens;* C, *B. nana;* D, *T. bacteriosperma* on *B. pubescens* (as *T. janus*); E, *B. pubescens;* F, *T. carnea* on *B. glandulosa;* G, *T. bacteriosperma* on *B. nana.*

B. intermedia. NORWAY: Finnmark, Skådevarre in Alta, July 30, 1924, I. Jørstad; Troms, Alterdet in Kvaenangen, July, 1900, C. J. Svendsen. SWEDEN: Härjedalen, Fjällnäs, June 23, 1933, A. G. Eliasson; Jämtland, Åreskutan, July 20, 1892, Juel; Jämtland, Foot of Snashögarna, July 20, 1889, E. H————g; Storlien, Aug. 24, 1939, A. J. M.; Lappland, Vassijaure, Aug., 1903, T. Vestergren (Micr. Rar. Sel. 721b); Pålnoviken, Aug. 20, 1939, A. J. M.

B. lutea. MAINE: Aquossoc, July 24, 1935, H. B. Peirson (U. S. D. A. Div. For. Path. 35289). ONTARIO: Lake Temagami, Metagama Point, June 27, 1929, H. S. Jackson [Univ. Toronto Crypt. Herb. 1045. Identified by Ray (1940) as *T. bacteriosperma*]. QUEBEC: Duchesnay, June 12, 1941, R. Pomerleau; Pontneuf, June 21, 1940, *id.*

B. nana. NORWAY: Opland, Storhang in Sør-Fron, July, 1893, A. Blytt. SWEDEN: Jämtland, Årestukan, July 20, 1884, C. J. Johanson (duplicate of type); Lappland, vicinity of Peskehaure, July 14, 1938, T. Arwidsson.

B. papyrifera. NEW HAMPSHIRE: Chocorua, May 21, 1911, R. Thaxter.

B. papyrifera var. *minor.* NEW HAMPSHIRE: Mt. Washington, July 3, 1939, D. H. Linder.

B. pendula. SWEDEN: Uppland, Ö. Ryd, Aug. 8, 1910, T. Vestergren (as *T. janus*).

B. pubescens. SWEDEN: Södermanland, road between Strängnäs and Lund, July 13, 1912, T. Holmgren and T. Vestergren (M. Rar. Sel. 1618, as *T. janus*); Tungelsta, B. Palm (as *T. lata*); Stockholm, Uggleviken, June 12, 1895, O. Juel (labelled "*Exoascus bacteriospermus* Joh—*janus* Thomas! teste Sadebeck").

Betula sp. NEW HAMPSHIRE: Mt. Washington, Lake of the Clouds, July, 1897, R. Thaxter; *ibid*, July 3, 1939, D. H. Linder, det. D. H. Linder. QUEBEC: Port Harrison, Aug. 6, 1936, N. Polunin, det. D. H. Linder.

Synonymy: a. Taphrina janus

Thomas (1897) although suggesting that *T. bacteriosperma, T. carnea,* and *T. janus* might actually be forms of the same fungus, described *T. janus* as a separate species, distinguishing it from *T. carnea* only by its amphigenous asci.

Actually it is not possible to distinguish *T. carnea* from *T. janus.* They are identical in their effect on the host, in size, shape, and basal compression of asci, and in producing asci upon one or both surfaces of the leaf.

b. Taphrina lata Palm

This fungus was described by Palm (1917) as causing enlargement and moderate thickening of leaves of *B. pubescens,* and affecting only young seedlings a foot or less tall. It was found only at Tungelsta, Sweden, near the railway station. He reported it as having asci 40-45μ × 18-22μ, with a stalk cell measuring 16-20μ × 25-33μ. The material studied by the writer consisted of a large packet among Lagerheim's collections, labelled only "Tungelsta, Palm." It contained a number of small seedling birches, with leaf-lesions corresponding closely to Palm's description. It seems highly probable that this is the material Palm used in describing *Taphrina lata.*

This is, however, typical material of *T. carnea.* The asci (lacking stalk cells) measure 36-60μ × 13-23μ, widening at the base and showing compression, exactly as in *T. carnea.* If this is Palm's fungus it is difficult to understand how he could have described it as having a stalk cell. In sections made by the writer asci with bases inserted and thus overlain by epidermal cells suggested asci with stalk cells. The mycelium is intercellular, not subcuticular as stated by Palm.

The occurrence of *T. carnea* on *B. fruticosa* Pall. (*B. gmelini* Bge.) is reported by Jaczewski (1926).

41. *Taphrina bacteriosperma* Johanson

Taphrina bacteriosperma Johanson, Bih. t. K. Svensk. Vetensk. Akad. Handl. **13**:3-28. 1897.
Exoascus bacteriospermus (Johans.) Sadebeck, Jahrb. Hamburg. Wissensch. Anst. **10**:5-110. 1893.

Causing yellowing of leaves, without thickening but sometimes with lateral enlargement, often affecting all the leaves of a shoot, but not causing witches' brooms, on *Betula glandulosa* Michx., *B. intermedia* Thom., *B. nana* L., *B. pubescens* Ehrh.

Mycelium subcuticular.

Asci epiphyllous, sometimes also hypophyllous, broad-cylindric, sometimes irregular, rounded or truncate at the apex, broadened at the base and often somewhat compressed by adjacent asci, lacking a stalk cell. Ascospores rarely seen, asci filled with minute bacterioidal blastospores (Fig. 17, A-E, G).

Dimensions: Of *asci,* 33-80μ × 14-20μ, widening at the base to 23-30μ; of *ascospores,* 3.6-4.5μ diam. (Johanson); of *blastospores,* 3-6μ × 1-2μ, or bacterioidal, 1-1.8μ × 0.5μ.

Distribution: Norway, Sweden, Greenland, Russia, North America.

Material examined: B. glandulosa. NEW HAMPSHIRE: Mt. Washington, near Lake of the Clouds, July 3, 1939, D. H. Linder, det. D. H. Linder.

B. nana. NORWAY: Dovrefjeld, foot of Mt. Nordra Kunestiö, July 9, 1933, A. G. Eliasson. SWEDEN: Härjedalen, Fjällnäs, July 27, 1933, O. Ostergren; Jämtland, Årestukan, Ulladalen, July 27, 1895, C. J. Johanson (Type).

B. pubescens. SWEDEN: Lappland, Abisko, July 28, 1911, O. Juel.

This species is not to be distinguished by the size of its asci from *Taphrina carnea.* A distinctive feature is the compression of the widened basal part of the ascus, where asci stand close together. Juel (1909) says that the asci are "grown together a little at the base."

Taphrina bacteriosperma causes no thickening of the leaves of its host, but often some lateral enlargement. Modification of leaf tissues is confined to the epidermis and palisade parenchyma; while *T. carnea* causes typical thickened "leaf-curl," with all mesophyll tissues modified. Since such variation in method of attack is possible within a single species (as indicated earlier for *Taphrina nana*) it would be interesting to compare these two fungi further by means of cultural studies and inoculations. Obviously they are closely related.

42. *Taphrina betulae* (Fkl.) Johanson

Taphrina betulae (Fkl.) Johanson, Ofvers. K. Svensk. Vetensk. Akad. Forhandl. **1885**:29-47. 1886.
Exoascus betulae Fuckel, Jahrb. Nassau. Verein. Naturk. **27** and **29**:1-99. 1873 and 1874.
Ascomyces betulae, Magnus, Rab. F. E. 2734.
Taphrina auctumnalis Palm, Arkiv. Bot. **15**:1-41. 1917.
Taphrina betulae (Fkl.) Johans. var. *auctumnalis* Sadebeck, Jahrb. Hamburg. Anst. **10**:5-110. 1893.

Causing small (up to 1 cm. diam.) pale green to yellow (brown in age) unthickened spots on leaves of *Betula intermedia* Thom., *B. medwediewi* Reg., *B. pendula* Roth., and var. *purpurea* Schneid., *B. pubescens* Ehrh., and *B. turkestanica* Litvin. Spots are evident on either surface of the leaf, showing as a pale area on the opposite surface.

Mycelium subcuticular.

Asci epiphyllous, hypophyllous or amphigenous, cylindric, rounded or truncate at the apex, sometimes broadened at the base. Stalk cells seated, broad and flat, broader than the ascus, or nearly isodiametric, not broader than the ascus. Ascospores eight, ovate to elliptic, sometimes budding in the ascus. (Fig. 18, A-E.)

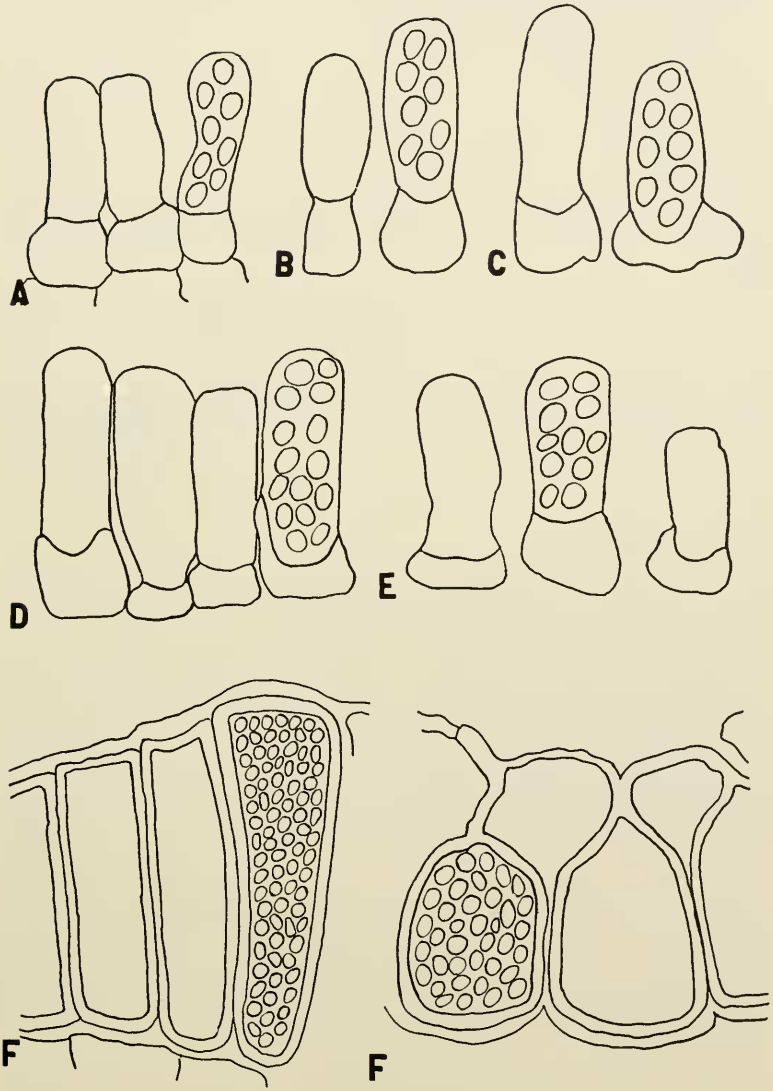

FIG. 18. Asci (× 900) of A-E, *Taphrina betulae*. A, on *Betula pendula*; B, *B. pubescens*; C, *B. intermedia*; D, *B. pubescens* (as *T. auctumnalis*); E, *B. medwediewi*; F, *T. flava* on *B. papyrifera*.

Dimensions: Of *asci*, 17-46μ × 8-18μ; of *stalk cells*, 7-17μ × 8-30μ; of *ascospores*, 4-6μ × 3.5-5μ.

Distribution: northern Europe.

Material examined: B. intermedia. SWEDEN: Lappland, Aug. 21, 1939, A. J. M.

B. medwediewi. RUSSIA: Causasus, Mt. Anczcha, Aug. 16, 1917, W. Siemaszko (Herb. W. S.).

B. pendula. GERMANY: Berlin, Thiergarten, June 12, 1880, P. Magnus (Rab.-Wint. F. E. 2734). SWEDEN: Grisslehamn, Sept. 9, 1912.

B. pendula var. *purpurea.* GERMANY: Berlin, Späth'sche Baumschule, Sept., 1891, P. Sydow (Myc. March. 3358).

B. pubescens. GERMANY: Berlin, Lichterfelde, Oct., 1895 (M. March. 4337, as var. *auctumnalis*); Hamburg, Wandsbek, Sept., 1891, Sadebeck (Munich Herb. Type of var. *auctumnalis*); Ö. Schlesien, Werdenau, June, 1913, J. Horuby (Petrak. Fl. Boh. Mor. Exs. Pilze 776). NORWAY: Bjsokeny, Aug., 1893, G. Lagerheim (as var. *auctumnalis*).

B. turkestanica. GERMANY: Berlin, Späth'sche Baumschule, Sept., 1898, P. Sydow (Myc. March. 3359).

Betula sp. SWEDEN: Sodermanland, Tungelsta, B. Palm.

Sadebeck (1893) described *T. betulae* var. *auctumnalis* on the basis of somewhat smaller asci, 15-27μ × 6-9μ; stalk cells 2-5μ high and very broad, stating that it occurred on *B. pubescens* and rarely on *B. pendula.* Palm in raising this variety to specific rank, confined it entirely to *B. pubescens,* calling the form on *B. pendula T. betulae.* There seems to be no basis for separation of the fungus here studied from *T. betulae* either as a variety or as a separate species, dimensions of asci and stalk cells falling well within those observed for *T. betulae.* Asci as short as 15μ or stalk cells as short as 5μ were not seen in Sadebeck's type material. Presumably, since this is an autumn form, it results from late primary or from secondary infection.

43. *Taphrina flava* Farlow

Taphrina flava Farlow, Proc. Amer. Acad. Arts and Sci. **18**:65-85. 1883.
Magnusiella flava (Farl.) Sadebeck, Jahrb. Hamburg. Wissensch. Anst. **10**:5-110. 1893.

Causing small (up to 5 mm.) yellow to brown or red-brown spots on leaves of *Betula papyrifera* Marsh., and *B. populifolia* Ait.

Mycelium intercellular.

Asci hypophyllous at first, later amphigenous, oblong (on upper epidermis) to squarish (on lower epidermis), arising from the ends of narrow hyphae. Ascospores rarely seen, asci filled with ovate to elliptic blastospores. (Fig. 18, F.)

Dimensions: Of *asci*, 30-63μ × 15-33μ; of *blastospores*, 5-6μ × 5-5.5μ, or minute.

Distribution: eastern North America.

Material examined: B. papyrifera. New Hampshire: Mt. Washington, carriage road, E. Faxon.

B. populifolia. Maine: Kittery Point, July 7, 1929, J. H. Faull (Herb. J. H. F. 9223). Massachusetts: Newton, W. G. Farlow (N. A. F. 300); Roxbury, July 4, 1888, A. B. Seymour (E. F. 171); Waverly, June 17, 1902, A. B. Seymour. New Hampshire: Mt. Washington, head of Great Gulf, July, 1886, W. G. Farlow. Nova Scotia: Lunenberg Co., Chester, July 22, 1929, J. H. Faull (Herb. J. H. F. 9252).

44. *Taphrina robinsoniana* Giesenhagen

Taphrina robinsoniana Giesenhagen, Flora **81**:267-361. 1895.
Exoascus robinsonianus Saccardo and Trotter, Sylloge Fungorum **22**:765.
Taphrina rugosa Ray, Mycologia **31**:56-75. 1939.

Causing protruding tongue-like enlargements of bracts and ovaries of female catkins of *Alnus incana* Moench., and *A. rugosa* Spreng. The tongues appear on the catkins near pollination time and are then very small: 2-3 mm. long. Later in the season when the fruits of the alder are well grown the tongues may measure several millimeters in length. Occasionally also causing leaf curl (involving all or part of the leaf), with typical thickening of leaves, on the same hosts.

Mycelium intercellular.

Asci occurring all over the surface of the tongue, amphigenous on leaves, cylindric, rounded or truncate at the apex, with a stalk cell which may be broader than the ascus and rather long. Ascospores eight, ovate to elliptic, often budding in the ascus, producing numerous ovate to elliptic blastospores. (Fig. 19, A-D.)

Dimensions: Of *asci*, 13-43μ × 6-17μ; of *stalk cells*, 6-20μ × 5-17μ; of *ascospores*, 2.5-6μ × 2.5-5μ.

Distribution: eastern North America.

Material examined: A. incana. Connecticut: Collinsville, Aug., 1926, A. J. M.; East Granby, Dec. 13, 1908, P. Spaulding (U. S. D. A. Div. For. Path. 2028). Maine: Byron, Aug. 25, 1938, A. E.

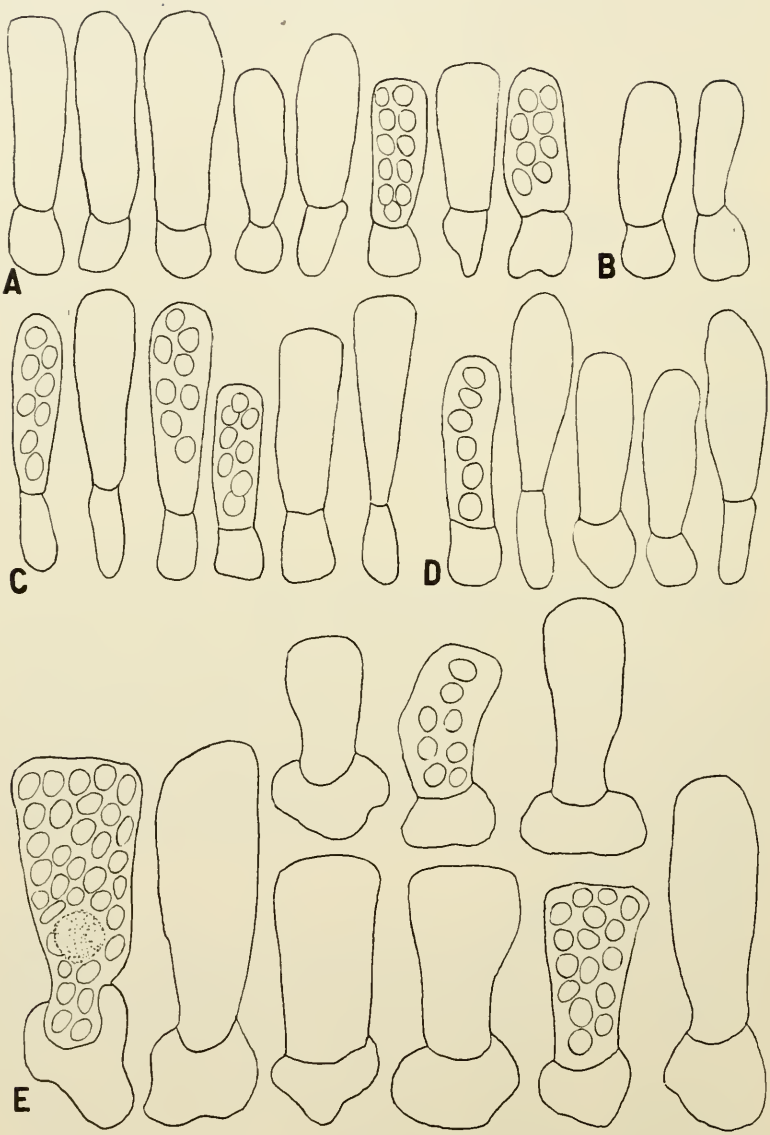

FIG. 19. Asci (× 900) of A, *Taphrina robinsoniana* on *Alnus incana;* B, C, *A. rugosa;* D, the same (*T. rugosa*); E, *T. sadebeckii.*

Prince; Ellsworth, Sept. 14, 1937, J. R. Hansbrough (U. S. D. A. Div. For. Path. 82125); Eustis, July 19, 1935, J. R. Hansbrough (Herb. J. R. H. 2385); Mt. Desert, Bar Harbor, J. S. Boyce (Herb. J. S. B. 2026); Hamden, July 5, 1938, A. E. Prince. Massachusetts: Amherst, Aug., 1934, R. H. Thompson; Granville, Aug. 3, 1885, A. B. Seymour (Econ. F. 167a); Jamaica Plain, Arnold Arboretum, July 28, 1892, A. B. Seymour. Michigan: Copper Harbor, Aug., 1928, A. J. M.; Empire, Aug. 10, 1938, E. A. Bessey. New Hampshire: Carroll, Cherry Mountain, July 27, 1926, P. Spaulding (For. Path. 45312). New York: Blue Mt. Lake, Aug. 24, 1934, G. E. Thompson (Cornell Univ. Dept. Plant Path. Herb. 23806); Ithaca, Ellis Hollow, June 22, 1940, A. J. M.; *ibid.*, July 15, 1940, *id.*; *ibid.*, July 23, 1940, *id.* North Carolina: Old Fort, Oct. 6, 1930, P. Spaulding. Vermont: Bethel, Sept., 1913, P. Spaulding (For. Path. 16833). New Brunswick: Fredericton, July 18, 1936, I. L. Connors (Cent. Expt. Farms Herb. 4518). Newfoundland: Harpoon River, Aug. 18, 1928, P. Spaulding (For. Path. 45640); Spruce Branch, Aug. 23, 1928, P. Spaulding (For. Path. 45649). Nova Scotia: Mahione Bay, Covey Island, July 20, 1936, H. T. Güssow (Cent. Expt. Farms Herb. 4527). Ontario: Lake Temagami, Bear Island, Aug. 10, 1930, I. L. Connors (Cent. Expt. Farms Herb. 1607); Sault Ste. Marie, Sept. 10, 1940, A. J. M. Quebec: Deschambault, I. L. Connors (Cent. Expt. Farms Herb. 1137); Farnham, Aug. 11, 1934, H. N. Racicot (Ottawa Div. Bot. Herb. 3727); Gaspé, Aug. 7, 1894, F. F. Forbes (Phanerogam. Herb. Stanford Univ.).

Alnus rugosa. Alabama: Auburn, April, 1891, G. F. Atkinson (Econ. F. 167b). Arkansas: New Hope, Oct. 15, 1932, D. Demaree (Phanerogam. Herb. Stanford Univ.). Connecticut: Collinsville, Aug. 23, 1937, A. J. M. Georgia: Athens, July 8, 1940; G. E. Thompson; Crawford, Oct. 17, 1935, J. H. Miller (Univ. of Georgia Herb. 2772); Experiment, April 9, 1937, W. A. Jenkins (Cornell Univ. Dept. Plant Path. Herb. 27346. Ray's type of *Taphrina rugosa*); *ibid.*, April 2, 1940, W. A. Jenkins; *ibid.*, April 8, 1940, *id.*; *ibid.*, April 22, 1940, *id.*; *ibid.*, May 2, 1940, *id.*; *ibid.*, May 20, 1940, *id.*; *ibid.*, Aug. 14, 1940, *id.* Massachusetts: Quincy, July, 1939, D. H. Linder (on both catkins and leaves); *ibid.*, Aug. 9, 1940, *id.* New York: Ithaca, June 23, 1940, A. J. M.; *ibid.*, July 12, 1940, *id.*; *ibid.*, Aug. 9, 1940, *id.* Tennessee: Montvale Springs, April 15, 1934, A. J. Sharp and L. R. Hesler (Univ. Tenn. Herb. 6094). Virginia: Fairfax Co., Black Pond, July 12, 1922, A. E. Jenkins.

Alnus sp. MASSACHUSETTS: Manchester, July 17, 1916, W. G. Farlow; Stony Brook, Oct., 1893, E. A. Burt; Wellesley, July 23, 1935, D. H. Linder; Worcester, July, 1924, H. E. Greenwood.

Ray (1939) described as a new species *Taphrina rugosa* on very small catkins of *Alnus rugosa,* using material collected by W. A. Jenkins at Experiment, Georgia. The distinguishing features were the very small, slender tongues, 2 or 3 mm. long, and the small asci (asci, 14-28μ × 4.5-9μ, stalk cells, 8-14μ × 6-10μ) and the small spores (2-4.5μ diam.) which were often 4 or 6 rather than 8 per ascus. Ray stated this to be a southern form, distinct from the common *Taphrina robinsoniana* of the northeast.

Since it seemed possible that *Taphrina rugosa* might be a juvenile stage of *T. robinsoniana,* probably to be found on both *Alnus incana* and *A. rugosa,* special study of the question was undertaken. In examination of Ray's type material no asci were seen so short as those reported by him, the dimensions observed being: Asci, 23-33μ × 8-10μ; stalk cells, 10-17μ × 5-8μ. Shorter asci were, however, observed later in certain other specimens.

Following examination of the type specimens a search was made among various collections for specimens of *Alnus incana* or *A. rugosa* showing very small tongues. The following were found: *A. incana,* Spruce Branch, Newfoundland, Aug. 23, 1928, P. Spaulding, tongues 2-3 mm. long, asci 16-36μ × 8-10μ, stalk cells 6-17μ × 8-13μ; Hamden, Maine, July 5, 1938, A. E. Prince, tongues 2-3 mm. long, asci 17-23μ×8-10μ, stalk cells 7-13μ×5-10μ. *A. rugosa,* Montvale Springs, Tennessee, April 15, 1934, A. J. Sharp and L. R. Hesler, tongues 2-3 mm. long, asci immature, only ascogenous cells being present; Black Pond, Virginia, July 12, 1922, A. E. Jenkins, tongues 5-8 mm. long, asci 20-30μ × 7-10μ, stalk cells 10-17μ × 7-10μ.

During a stay at Cornell University in 1940 the writer received through the kindness of Dr. W. A. Jenkins specimens of *"Taphrina rugosa"* on *Alnus rugosa* collected by him on April 2, April 22, May 2, May 20, July 8, and August 14. In the first two of these collections only a few very short tongues were evident and the fungus was immature. Doctor Jenkins suggested (in a letter of April 9) that the overgrowths were from enlarged ovaries rather than from bracts. This is true of the earliest outgrowths observed but in the material collected April 22 and later, as well as in the specimens discussed above, both ovaries and bracts were enlarged. Contiguous bracts and ovaries may show tongues.

In the collection of April 22 the tongues were 2-3 mm. long, and

a few mature asci were present, measuring 26-33μ × 7-10μ, stalk cells 10-13μ × 8-10μ. In the collection of May 2, the tongues were 5-10 mm. long and 2-3 mm. wide. On tongues from ovaries asci were 13-33μ × 7-10μ, stalk cells 18-17μ × 7-10μ; on those from bracts asci measured 23-40μ × 7-10μ, stalk cells 13-17μ × 7-10μ. In the collection of May 20 the tongues were 1 to 3 cm. long, although the catkins were still very small. Asci measured 26-36μ × 8-10μ, stalk cells 8-20μ × 8-13μ.

It is to be noted that in the earliest collections showing mature asci some of these asci were large enough to be characteristic of *Taphrina robinsoniana*. Ascospores measured 4.5-5μ × 4-4.5μ and were frequently 4 or 6 per ascus rather than 8. In the specimens of May 20, eight-spored asci were more common and some asci contained blastospores.

In the collections of July 8 and August 14 the outgrowths were long (typical of *T. robinsoniana*) and asci measured 26-32μ × 7-9μ; stalk cells 8-13μ × 7-13μ.

Alnus rugosa is rare in the vicinity of Ithaca but a few trees occur in Stewart Park along Cayuga Lake Inlet. These were visited on May 14, 1940, when the male catkins were shedding pollen. A week later pollination was over although styles and stigmas were still evident. There was no sign of fungus attack. Observations were continued at weekly intervals and on June 23, a number of reddish tongues, about 2 mm. long, were seen protruding from some catkins. These catkins were still very small, about "pollination-size," styles and stigmas were still evident, and the catkins were quite like those in the early collections received from Georgia.

Weekly visits to these alders were continued and the gradual enlargement of the outgrowths watched. It became evident that the large "summer" tongues characteristic of *T. robinsoniana* are enlarged states of the very small early outgrowths.

Collections were made on June 23, July 12, and August 9. On July 12 infected leaves were also collected. These collections may be summarized as follows:

June 23, tongues 2 mm. long, asci 20-26μ × 8-10μ, stalk cells 8-10μ × 7-10μ, spores often 6 per ascus, 4.5μ × 4μ.

July 12, tongues 5 mm. long, asci 26-40μ × 8-12μ, stalk cells 8-20μ × 8-12μ, spores often 8 per ascus, 4.5-5μ × 8-12μ, blastospores present.

August 9, tongues 2 cm. long, asci 26-36μ × 8-12μ, stalk cells 10-17μ × 8-12μ, spores mostly blastospores.

On the curled leaves collected July 12, the amphigenous asci measured 17-26μ × 7-10μ, stalk cells 7-10μ × 7-10μ. This is in agreement with observations made on material collected at Quincy, Massachusetts, July, 1939, by D. H. Linder. In these specimens asci from catkins measured 23-40μ × 8-12μ, stalk cells 13-20μ × 7-13μ, asci from leaves 23-26μ × 7-10μ; stalk cells 10-17μ × 7-13μ. Evidently asci formed on leaves are regularly somewhat smaller than those on catkins, a fact already noted for *T. robinsoniana* by Ray (l. c.).

Coincident with these observations of the fungus on *Alnus rugosa,* its development on *A. incana* was watched. Specimens of these alders growing at Ellis Hollow, near Ithaca, were inspected at frequent intervals beginning May 15. Collections were made on June 22, July 15, and July 23. Observations were as follows:

June 22, tongues 1-2 mm. long, asci 20-33μ × 8-10μ, stalk cells 8-17μ × 8-13μ, spores mostly 8 per ascus, 4-6μ × 4-4.5μ.

July 15, tongues 1 cm. long, asci 17-36μ × 8-10μ, stalk cells 8-16μ × 8-13μ, spores 5-6μ × 4.5-5μ, mostly blastospores.

July 23, tongues 1-1.5 cm. long, asci 26-43μ × 10-13μ, stalk cells, 8-17μ × 7-10μ, spores mostly blastospores.

Infected leaves were collected on July 23. On these the asci were somewhat smaller than on the catkins.

From these observations two conclusions are inescapable: that there is no morphological distinction between *Taphrina robinsoniana* on *Alnus incana* and on *Alnus rugosa,* and that *Taphrina rugosa* is a juvenile stage of *T. robinsoniana.*

American collectors have been slow to recognize the identity of *Taphrina robinsoniana* and many collections have been reported as *T. alni-incanae* (Kühn) Magn. [*T. amentorum* (Sadeb.) Rostr.]. Conners (1932) has mentioned this error in identification and has suggested the probability that *Taphrina amentorum* does not occur in eastern North America. Conners' suggestion led to the examination of a very large number of collections (listed above). All specimens proved to be *Taphrina robinsoniana. Taphrina amentorum* on *Alnus rubra* has been reported from Alaska (Ray, 1939).

45. *Taphrina sadebeckii* Johanson

45. *Taphrina sadebeckii* Johanson, Ofv. of K. Svensk. Vetensk. Akad. Forhandl. 1885:29-47. 1886.
Exoascus alni de Bary in Litt., in part.
Exoascus flavus Sadebeck, Jahrb. Hamburg. Wissensch. Anst. 1:93-124. 1884.
Exoascus epiphyllus Sadeb. var. *maculans* Sadebeck, Jahrb. Hamburg. Wissensch. Anst. 8:61-95. 1890.

Ascomyces tosquinetii Westerdorp, Bull. Acad. Roy. Sci. Lett. et Beaux-arts Belgique 2 ser. 11:644-660. 1861, in part.

Causing moderate-sized (up to 1 cm. diam.) yellow spots on leaves of *Alnus glutinosa* Gaertn., *A. hirsuta* Turcz., *A. hirsuta* Turcz. var. *sibirica* Schneid., and *A. rugosa* Spreng.

Mycelium intercellular.

Asci hypophyllous, sometimes also epiphyllous, cylindric, rounded or more often truncate at the apex, often with pale yellowish epiplasm, inserted in a broad stalk cell (often broader than the ascus). Ascospores eight, ovate to elliptic, frequently budding in the ascus. Ascus emerging from the chlamydospore (ascogenous cell) by rupture of the chlamydospore wall. (Fig. 19, E.)

Dimensions: Of *asci,* 17-65μ × 10-21μ; of *stalk cells,* 7-23μ × 13-30μ; of *ascospores,* 4-6μ × 3.5-5μ.

Distribution: Europe, Japan.

Material examined: Alnus glutinosa. Denmark: Jylland, Viborg, June 15, 1903, J. Lind. Germany: Brandenburg, Triglitz, July 20, 1903, O. Jaap (Myc. Ger. 172); Hamburg, Eppendorfer Moor, July, 1930, A. J. M. Ireland: County Wicklow, Killadreenan House, June 22, 1935, A. J. M. Sweden: Stockholm, Lidingö, July 22, 1884, J. Erikson (F. Par. Exs. 226); Rydbo, Aug. 6, 1939, A. J. M.; Statens Växtskydds Anstalt, Aug. 12, 1939, A. J. M.

A. hirsuta. Germany: Berlin, Sept., 1891, P. Sydow (Myc. March. 1360). Japan: Iwate, Mt. Himekami, June 15, 1907, G. Yamada (Herb. Morioka Imp. Coll. Agric. and For., as *T. epiphylla*); Mt. Hayachine, June 13, 1909, *id.* (as *T. epiphylla*).

A. rugosa. Sweden: Stockholm, Bergianska Trädgården, Aug. 10, 1939, A. J. M.; *ibid.,* Aug. 11, *id.*; *ibid.,* Aug. 12, *id.*

Sadebeck reports this fungus on *A. hybrida* A. Br. Three collections so labelled were found in exsiccati: Krieger, F. Sax. 70 (Königstein, Aug.-Sept., 1904, W. Krieger), and Herb. K. Starcs (Riga, Latvia, July 30, 1930, Gulbene, Lithuania, Aug. 30, 1931, K. Starcs). In these collections the host seems to be *Alnus incana,* and the fungus *Taphrina epiphylla.* Occurrence of *T. sadebeckii* in Russia on *A. hirsuta* var. *sibirica* Schneid. is reported by Jaczewski (1926).

Of interest is the occurrence of this fungus in Sweden on the American alder *Alnus rugosa.* The trees observed were heavily infested, indicating that if *Taphrina sadebeckii* were introduced into eastern North America a susceptible host would be waiting.

46. *Taphrina tosquinetii* (Westend.) Tulasne

Taphrina tosquinetii (Westend.) Tulasne, Ann. Sci. Nat. 5 Ser., Bot. **5**:122-136. 1866.
Ascomyces tosquinetii Westendorp, Bull. Acad. Roy. Sci. Lett. and Beaux-arts Belgique. 2 Ser. **11**:644-660. 1861.
Taphrina alnitorqua Tulasne, Ann. Sci. Nat. 5 Ser. Bot. **5**:122-136. 1866, in part.
Exoascus alnitorquus Sadebeck, Jahrb. Hamburg Wissensch. Anst. **1**:93-124. 1884, in part.
Exoascus alni de Bary in litt., in part.
Taphrina media Palm Arkiv. Bot. **15**:1-41. 1917.

Deforming leaves (leaf-curl of part or whole blade) of *Alnus crispa* (Ait.) Pursh. var. *mollis* Fern., *A. glutinosa* Gaertn., and *A. hybrida* A. Br. Affecting whole shoots or shoot-systems, but not forming true witches' brooms.

Mycelium subcuticular, perennial.

Asci amphigenous, cylindric, truncate at apex, stalk cells inserted between epidermal cells. Ascospores eight, often budding in ascus, ovate to elliptic. Ascus emerging from the chlamydospore (ascogeous cell) by rupture of the chlamydospore wall. (Fig. 22, B-D.)

Dimensions: Of *asci*, 17-40μ × 7-13μ; of *stalk cells*, 7-17μ × 8-17μ; of *ascospores*, 2.5-5.5μ × 2.5-5μ.

Distribution: Europe.

Material examined: A. crispa var. *mollis*. NEW HAMPSHIRE: Lyme Center, Holt's Ledge, June 26, 1929, H. H. Whetzel and D. S. Welch (Herb. Cornell Univ. Dept. Plant Path. 17566).

Alnus glutinosa. BELGIUM: Vallée de Munster (Ht. Rhin.), Aug. 25, 1872 (Herb. Inst. Bot. Strasbourg). GERMANY: Brandenburg, between Ruhlsdorf and Marienweder, Aug. 6, 1920, H. and P. Sydow (Myc. Germ. 1648); Hamburg, Eppendorfer Moor, July, 1930, A. J. M.; Thuringia, between Jescha and Berka, near Sondershausen, Sept. 6, 1905, G. Oertel (Myc. Germ. 492). IRELAND: County Wicklow, Killadreenan House, June 23, 1935, A. J. M.; Killarney, June 19, 1935, A. J. M. SWEDEN: Göta Canal near Tröllhattan, Aug. 26, 1935, A. J. M.; Rådmansö, July 9, 1939, A. J. M.; Tungelsta, July 13, 1939, A. J. M.; Virabruk-i-Rosslagskulle, July 18, 1939, A. J. M. (loc. class. for *T. media*).

A. hybrida. GERMANY: Hamburg, Eppendorfer Moor, June 9, 1905, O. Jaap (F. Sel. Exs. 305b).

Palm (1917) described *Taphrina media* as intermediate between *T. tosquinetii* and *T. epiphylla*. Apparently he meant to give dimensions of asci as 25-30μ × 10-12μ, and they are so stated in his key to species, but in his species-description length of asci is given as 25-90μ. Obviously this is a typographical error; it has been pre-

served by later writers. Since Palm left no type specimen of *Taphrina media* and no specimen of any fungus collected by Palm on *Alnus glutinosa* was to be found among Lagerheim's collections, a visit was paid on July 18, 1939 to the type-locality, Virabruk. (This was arranged through the kindness of Dr. T. Arwidsson.)

Virabruk is an abandoned iron foundry, and the alders along the brook running through it are comparatively few, so that a thorough search was easily accomplished. The so called "witches' brooms" pictured by Palm (his figure 4) were easily found, appearing as upturned clusters of twigs at the ends of branches on the larger alders. They were entirely free of any fungus, and whatever their cause, were obviously not due to the action of any species of *Taphrina*. Palm must have collected his fungus from the diseased shoots of the younger alders nearby. These shoots were attacked by *Taphrina tosquinetii*, and this fungus was the only species of *Taphrina* to be found at Virabruk. The collection of *T. tosquinetii* made there showed asci 20-30μ × 8-13μ; stalk cells, 8-17μ × 10-13μ. The asci could be considered intermediate between those of *T. tosquinetii* and those of *T. epiphylla* if the dimensions of those fungi as given in the literature were correct. If the revised dimensions of *T. tosquinetii* (as given above) are considered, the asci clearly belong to that fungus. It must be concluded that Palm was in error in thinking he had a new species and that the fungus he described was *Taphrina tosquinetii*.

The fungus on *Alnus crispa* var. *mollis* was identified by Dr. A. E. Jenkins as *Taphrina media* Palm. A letter from Prof. H. H. Whetzel to Dr. C. L. Shear is enclosed with the specimens in the Cornell Herbarium. This states: "The effect on the plant is that of systemic invasion, a sort of witches' broom, the affected leaves standing up in a staring fashion." This description might apply to the effect of *Taphrina tosquinetii* on *Alnus glutinosa*. The asci of the New Hampshire fungus are shorter than the longest asci observed in *T. tosquinetii*, measuring 16-26μ × 8-13μ; stalk cells 8-13μ × 8-15μ. The ascus emerges from the chlamydospore in the same manner as in *T. tosquinetii*. It seems better to assign this fungus to *Taphrina tosquinetii*, even though that fungus is not heretofore known from North America, than to erect a new species on the basis of this one collection.

47. *Taphrina amentorum* (Sadeb.) Rostrup

Taphrina amentorum (Sadeb.) Rostrup, Vidensk. Meddel. Naturh. Foren. Kjøbenhavn. **1890**:246-264.
Exoascus amentorum Sadebeck, Sitzungsber. Ges. Bot. Hamburg **4**:90. 1888.
Ascomyces alni Berkeley and Broome, Ann. and Mag. Nat. Hist. **17**:129-145. 1876.
Exoascus alnitorquus (Tul.) Sadebeck var. *alni-incanae* J. Kühn. (Fungi Europaei 1616.)
Taphrina alni-incanae (Kühn) Sadebeck, Jahrb. Hamburg Wissensch. Anst. **8**:16-95. 1890.
Exoascus alnitorquus (Tul.) Sadebeck, Jahrb. Hamburg Wissensch. Anst. **1**:93-124. 1884, in part.
Exoascus alni de Bary, in litt., in part.
Exoascus alni de Bary var. *strobilinus* Thümen, Flora **63**:312-322, 323-332. 1880.
Ascomyces tosquinetii Westend. var. *strobilina* Rostrup, Tidskr. f. Skovbrug **4**:113-206. 1880.

Causing rather large (larger than those caused by *T. robinsoniana*) tongue-like outgrowths from the female catkins of *Alnus glutinosa* Gaertn., *A. hirsuta* Turcz., *A. hybrida* A. Br., *A. incana* Moench, and *A. rubra* Bong.

Mycelium intercellular.

Asci cylindric, truncate at apex, lacking a stalk cell, inserted between epidermal cells, Ascospores eight, often budding in the ascus, ovate to elliptic. Asci emerging from the chlamydospore (ascogenous cell) by rupture of the chlamydospore wall. (Fig. 20, A-C.)

Dimensions: Of *asci*, 26-53μ × 10-23μ; of *ascospores*, 4.5-6μ × 4-5μ.

Distribution: Europe, Japan, Alaska.

Material examined: A. glutinosa. GERMANY: Mecklenburg, Warnemünde, Aug. 16, 1904, O. Jaap. (F. Sel. Exs. 78a).

A. hirsuta. JAPAN: Iwate, Gomyojin, Aug. 17, 1907, G. Yamada (Herb. Morioka Imp. Coll. Agric. and For.).

A. hybrida. GERMANY: Mecklenburg, Warnemünde, Aug. 16, 1904, O. Jaap. (F. Sel. Exs. 78b).

A. incana. GERMANY: Bavaria, Lechufer near Fussen, Aug. 18, 1912, H. Sydow (Myc. Ger. 1111); Pomerania, Ruhgenmahdermünde, Sept., 1894, P. Sydow (Herb. Sydow). POLAND: Pieniny, Aug., 1928, W. Siemaszko (Herb. Inst. Phytopath. Schol. Sup. Agric. Varsaviensis).

A. rubra. ALASKA: Lake Pironsi Glacier, B. E. Fernow (Phanerogam Herb. Cornell Univ.).

This fungus has been widely known as *Taphrina alni-incanae* (Kühn) Magnus. As Ray (1939) has pointed out, the first description was by Sadebeck (1888) who called it *Exoascus amentorum.*

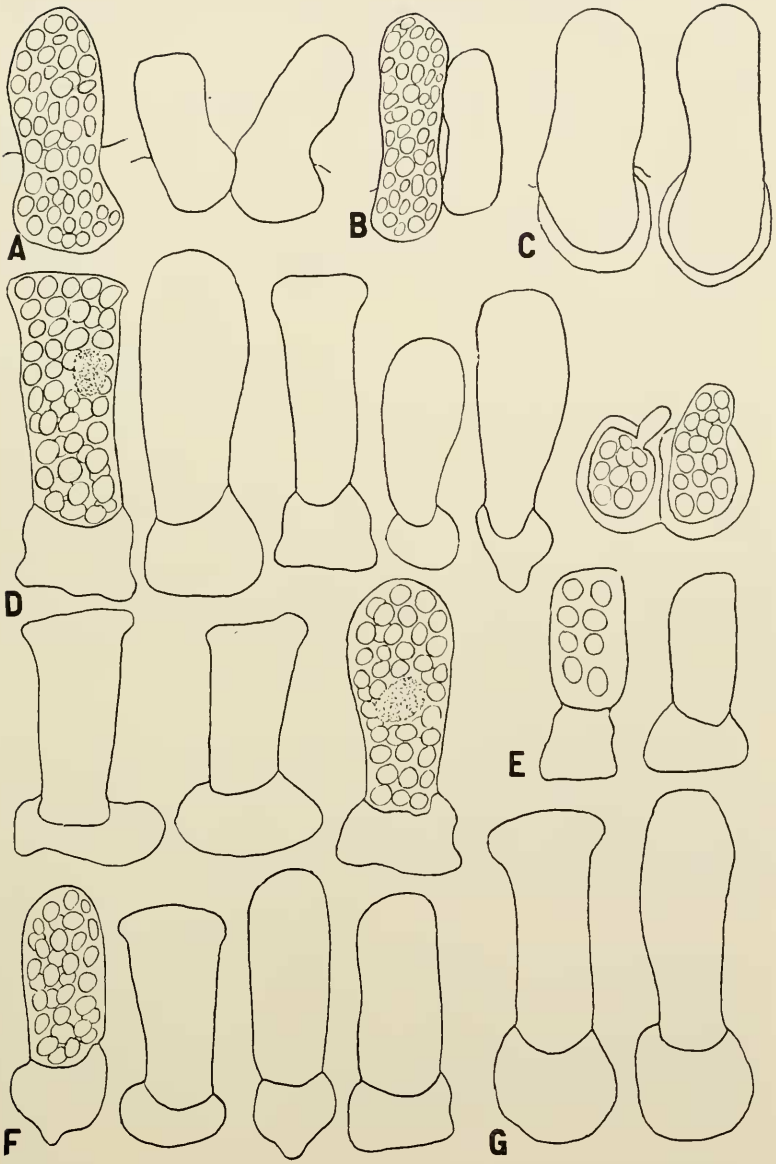

Fig. 20. Asci (× 900) of A, *Taphrina amentorum* on *Alnus glutinosa;* B, *A. incana;* C, *A. hybrida;* D, *T. epiphylla* on *A. incana;* E, *A. incana* f. *aurea;* F, G, *T. epiphylla* (*T. klebahni*).

Rostrup (1890) transferred it to *Taphrina*, it thus becoming *Taphrina amentorum* (Sadeb.) Rostrup. Ray (1939) has been the first to record the occurrence of this fungus on the North American continent.

48. *Taphrina epiphylla* Sadebeck

Taphrina epiphylla Sadebeck, Jahrb. Hamburg Wissensch. Anst. **8**:61-95. 1890.
Exoascus epiphyllus Sadebeck, Jahrb. Hamburg Wissensch. Anst. **1**:93-124. 1884.
Taphrina sadebeckii Johans. var. *borealis* Johanson, Ofvers. K. Svensk Vetensk. Akad. Forhandl. **1885**:29-47. 1886.
Taphrina borealis Johanson, Bih. K. Svensk Vetensk. Akad. Handl. **13**:3-28. 1887.
Taphrina klebahni Wieben, Forsch. auf Geb. Pflanzenkr. und Immun. in Pflanzenr. **3**:139-176. 1927.

Causing witches' brooms and (in midsummer) yellowish spots on leaves of *Alnus incana* Moench. Leaves not thickened.

Mycelium subcuticular, perennial.

Asci amphigenous, broad-cylindric, usually truncate and often abruptly widened at the apex to a flat head, inserted in a broad stalk cell which may be truncate or pointed below. Ascospores eight, ovate to elliptic, commonly budding in the ascus. Pale yellowish epiplasm present. Asci emerging from the chlamydospore (ascogenous cell) by rupture of the chlamydospore wall. (Fig. 20, D-G.)

Dimensions: Of *asci*, 20-60μ × 10-23μ; of *stalk cells*, 7-20μ × 10-30μ; of *ascospores*, 4-7μ × 4-7μ.

Distribution: Europe.

Material examined: GERMANY: Berlin, Aug., 1891, P. Sydow (Myc. March. 3757, host given as *A. hybrida* but evidently *A. incana*); Hamburg, Eppendorfer Moor, July, 1930, A. J. M. (two collections); Rhine province, Westerwald, Stegskopf, July 30, 1922, A. Ludwig (Mye. Ger. 1956). NORWAY: Orkedalen, July 16, 1887, J. Brunchorst (Herb. Växtskyddsanstalt, Stockholm; host given as *A. glutinosa* but evidently *A. incana*). POLAND: Wilno, June 10, 1928, W.; Konopacka (Herb. Inst. Schol. Sup. Agric. Varsaviensis). SWEDEN: Jämtland, Hålland, July 23, 1915, O. Juel; Lappland, Abisko, Aug. 17, 1939, A. J. M.; *ibid.*, Aug. 21, 1939, *id.*; Stockholm, Bergianska Trädgården, July 3, 1939, A. J. M. (collections on *A. incana*, *A. incana* var. *monstrosa* Winkl., and var. *aurea* Schelle.)

The following were collected as *Taphrina klebahni*: GERMANY: Hamburg, Eppendorfer Moor, July, 1930, A. J. M. (two collections). NORWAY: Ulvik, Aug. 18, 1935, A. J. M. SWEDEN: Stockholm, Ber-

gianska Trädgården, Aug. 10-12, 1939, A. J. M. (collections on *A. incana, A. incana* var. *aurea* and var. *monstrosa*).

Wieben (1927) did not give dimensions of the stalk cells of *Taphrina klebahni,* though from her description of the fungus it is clear that she recognized their occurrence. The collections from Eppendorfer Moor, Hamburg (the type-locality) were made with the assistance of Miss Wieben.

Taphrina klebahni is evidently a late summer form of *T. epiphylla.* The first spots appear after the leaves of the witches' brooms have borne asci and ascospores have been discharged. These spots apparently result from infection by ascospores (or blastospores), and presumably the resulting mycelium may overwinter and cause a new witches' broom.

There is no morphological distinction between *Taphrina epiphylla* and *T. klebahni.* Both have the same curious "tack-headed" asci and the same pale-yellowish epiplasm. In size of asci, stalk cells, and spores they are alike.

Both fungi seem to have the same biologic specialization. In the Hortus Bergianus at Stockholm a plantation of *Alnus* was under observation during the summer of 1939. Specimens of *Alnus incana,* of *A. incana* var. *aurea,* and var. *monstrosa,* and of a variety with pendulous branches, all showed witches' brooms of *T. epiphylla* when observed early in July. In August when most of the leaves had fallen from these witches' brooms, a heavy infestation of *T. klebahni* appeared on the same trees. A specimen of *A. incana* var. *oxycanthoides* Schotte, whose branches intermingled with a tree of *A. incana* var. *aurea* remained free from both fungi, as did a nearby tree of *A. incana* var. *curvatipinnatifida* Wittr. Specimens of *Alnus rugosa* (from North America) were heavily infested by *Taphrina sadebeckii* and specimens of *Alnus cordata* Desf., and *A. viridis* DC showed no signs of fungus attack.

The spots caused by *Taphrina klebahni* are usually small, one-half to 1 cm. in diameter, but in the specimens collected at Ulvik, Norway, all or nearly all of the leaf was involved, and only the absence of witches' brooms differentiated the fungus from typical *Taphrina epiphylla.* Apparently the shoot-system was being attacked by way of the leaves, and witches' brooms might be expected to follow.

Wieben (1927) reported copulation of ascospores (or blastospores) for both *Taphrina epiphylla* and *T. klebahni.* This phenomenon has not been observed to occur regularly in any other species.

49. *Taphrina japonica* Kusano

Taphrina japonica Kusano, Bot. Mag. Tokyo, **19**:1-5. 1905, also Ann. Mycol. **3**:30-31. 1905.
T. alni-japonicae Nishida, Miyabe Fertschrift. Tokyo, 1911.
T. macrophylla Ray, Mycologia **32**:155-158. 1940.

Causing leaf curl with thickening, affecting part or all of the blade, on leaves of *Alnus japonica* Sieb. and Zucc., and *A. rubra* Bong.

Mycelium subcuticular.

Asci amphigenous, broad-cylindric, rounded at the apex, frequently truncate at the base and broadened to a one-sided foot, lacking a stalk cell. Ascospores eight, globose, frequently budding in the ascus, filling it with ovate to elliptic blastospores (Fig. 21, A-C.)

Dimensions: Of *asci,* 33-92μ × 13-33μ, widening at base to 40μ (if considered separately, *T. japonica* 46-92μ × 23-33μ, *T. alni-japonicae* 36-85μ × 17-28μ, *T. macrophylla* 36-86μ × 13-26μ), of *ascospores,* 4-5.5μ×4-5-5.5μ, of *blastospores,* 2-6.5μ×2-5μ.

Distribution: Japan, Pacific coast of North America.

Material examined: Alnus japonica. JAPAN: Fukui, Tsudogama, May 6, 1922, T. Asano; Ichikawa, June 9, 1907, S. Kusano; Iwate, Morioka, June 21, 1904, G. Yamada (as *T. alni-japonicae*); *ibid.,* July 26, 1905, *id.*; Tokyo, Botanic Garden, May 6, 1904, S. Kusano (duplicate of type of *T. japonica*).

A. rubra. ALASKA: June 26, 1923, J. P. Anderson. CALIFORNIA: Humboldt Co., Trinidad, March 24, 1931, H. E. Parks (Herb. Univ. California 3592). OREGON: Tillamook Co., Siuslaw National Forest, Hebo, May 9, 1923, J. S. Boyce (Herb. J. S. B. 1182).

Apparently *Taphrina japonica* Kusano, *T. alni-japonicae* Nishida, and *T. macrophylla* Ray are one and the same fungus, for which the name *T. japonica* has priority. *Taphrina japonica* is said by Kusano to form witches' brooms, but judging from the way this term is employed by many writers his statement may merely mean that whole shoots and shoot-systems are affected. At any rate the curled leaves produced by *T. alni-japonicae* may well be due to infection by a fungus which will later induce a witches' broom or deform a whole shoot (similar situations exist in *Taphrina cerasi* and other witches'-broom formers). The leaves on the Japanese specimens are not so greatly enlarged as in the American specimens of the fungus on *Alnus rubra.* This may either be a host-effect, or a difference that would disappear if more abundant Japanese material were at hand.

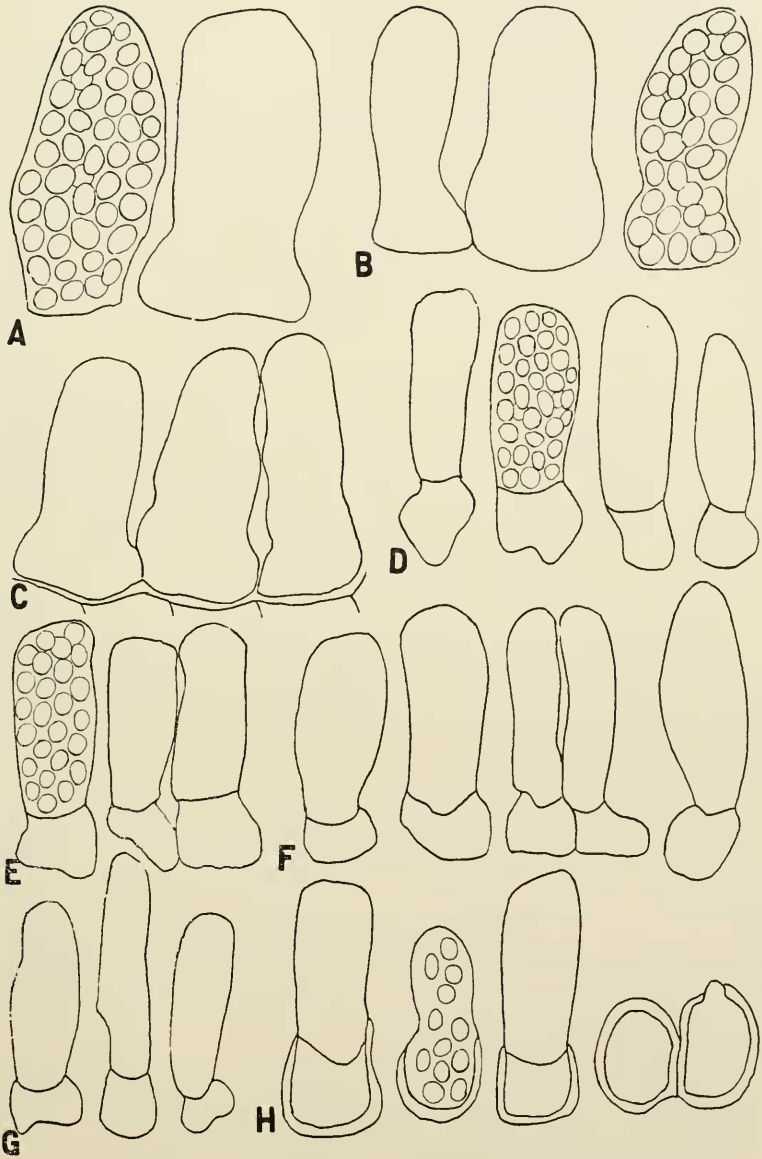

FIG. 21. A-C, asci (× 900) of *Taphrina japonica*, (B, as *T. alni-japonicae*, C, as *T. macrophylla*). D-H, *T. occidentalis*; D, E, on *Alnus rubra*; F, *A. tenuifolia*; G, *A. sinuata*; H, *A. rhombifolia*.

The asci are alike in form and size. Measurements of the asci of the three forms are given above. Asci of each fungus may widen at the base to a broad diameter of 40μ.

Ray (l. c.) states that in *Taphrina japonica* "the basal portion of the ascus is rounded and not widened as is often the case of the asci on the leaves of *A. rubra*." Actually the asci of *Taphrina japonica*, of *T. alni-japonicae* and of the fungus on *Alnus rubra* are alike. They may be rounded at the base, or truncate and widened, the widened portion often taking the form of a bilateral or unilateral foot. Since there are no morphological differences between these three fungi they are hereby declared synonymous as *Taphrina japonica* Kusano.

The fungus deforming the leaves of *Alnus rubra* had been described and discussed (Mix, 1939) before Ray's description appeared, the question having been left open as to its identity with the two Japanese fungi. The collection designated as the type of *T. macrophylla* was not the earliest collection of the fungus, that being the one made by Boyce at Hebo, Oregon, May 9, 1923.

50. *Taphrina occidentalis* Ray

Taphrina occidentalis Ray, Mycologia **31**:56-75. 1939.

Causing tongue-like enlargements of bracts of female catkins of *Alnus rhombifolia* Nutt., *A. rubra* Bong, *A. sinuata* Ryd., and *A. tenuifolia* Nutt. Also causing small puffed or curled areas on the leaves of *A. rhombifolia*.

Mycelium subcuticular.

Asci covering surface of outgrowth, cylindric or cylindric-clavate, rounded or truncate at the apex, with a stalk cell that is commonly broader than long, truncate, rounded, pointed, or irregular below, seated or somewhat inserted between epidermal cells. Ascospores eight, round, ovate, or elliptic, frequently budding in the ascus, filling it with smaller ovate or elliptic blastospores. Asci emerging from the chlamydospore (ascogenous cell) by rupture of the chlamydospore wall. (Fig. 21, D-H, Fig. 22, A.)

Dimensions: Of *asci*, 20-60μ × 8-20μ; of *stalk cells*, 5-23μ × 7-23μ; of *ascospores*, 4-6μ × 3.5-6μ; of *blastospores*, 3.5-5μ × 3-4μ.

Distribution: Western North America.

Material examined: Alnus rhombifolia. CALIFORNIA: Lake Co., Putah Creek, Sept., 1931, H. E. Parks (Herb. Univ. Calif. 3883); Monterey Co., Sur River, Aug., 1903, W. R. Dudley (Phanerogam. Herb. Stanford Univ.); Santa Clara Co., Los Gatos Creek, Oct. 11,

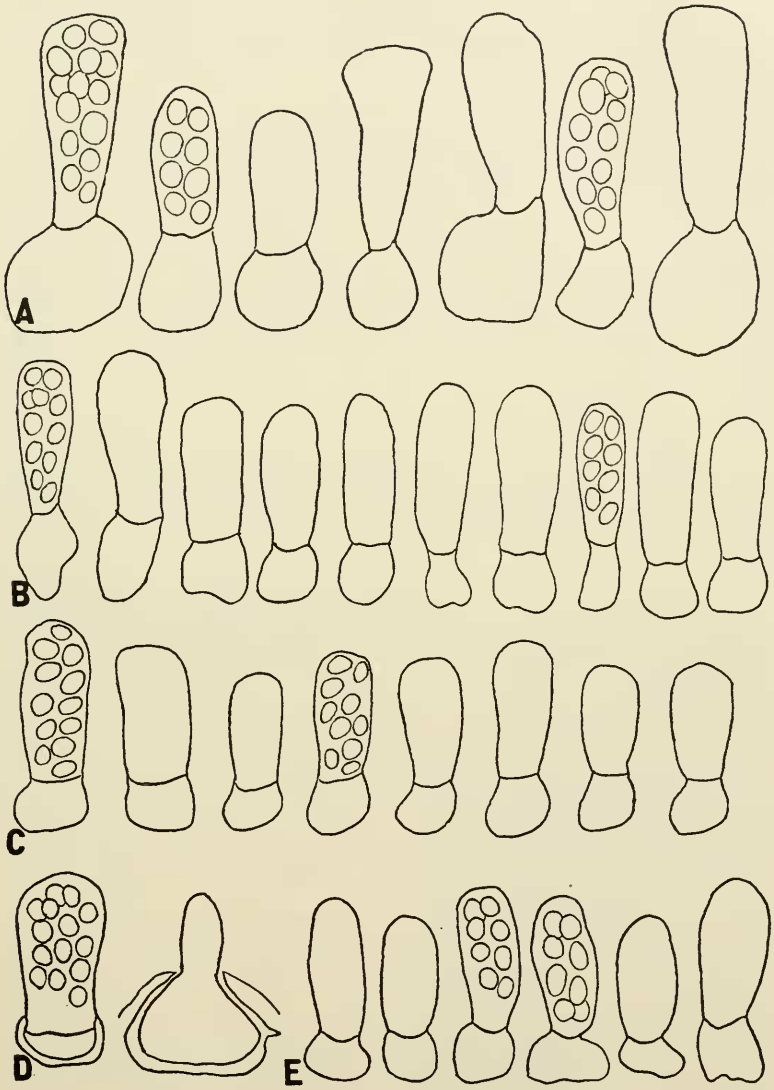

Fig. 22. Asci (×900) of A, *T. occidentalis* on *Alnus rhombifolia;* B, *T. tosquinetii* on *A. glutinosa;* C, *A. crispa* var. *mollis;* D, the same showing emergence of ascus from chlamydospore; E, *Taphrina viridis.*

1902, W. R. Dudley (Phanerogam. Herb. Stanford Univ.). OREGON: Prospect, Rogue River, Aug. 7, 1929, G. D. Darker (Herb. Arnold Arboretum, 456); Sucker Creek below junction with Grayback Creek, Aug. 14, 1929, G. D. Darker (Herb. Arnold Arboretum 575).

A. rubra. BRITISH COLUMBIA: D'Arcy, June 28, 1931, J. R. Hansbrough (Herb. J. R. H. 605); Owl Creek, June 18, 1930, *id.* (Herb. J. R. H. 606); Vancouver Island, Sooke, July, 1938, Malcolm Wilson. CALIFORNIA: Mill Valley, H. E. Parks (Fungi of California 2596); Humboldt Co., Sur P. O., Aug. 3, 1903, W. R. Dudley (Phanerogam. Herb. Stanford Univ.); Siskiyou Co., Klamath Nat. For., Deer Camp Ranger Station, Aug. 26, 1913, E. P. Meinecke and J. S. Boyce (Herb. J. S. B. 278). OREGON: Corvallis, Jan. 30, 1938, Wm. Bridge Cooke; Grant's Pass, Sept. 5, 1917, J. R. Weir (Herb. J. R. W. 5214. Type.)

A. sinuata. OREGON: Government Camp, July 23, 1929, G. D. Darker (Herb. Arnold Arboretum 357); Oregon Caves, Lake Mountain Trail, Aug. 12, 1929, G. D. Darker (Herb. Arnold Arboretum 532).

A. tenuifolia. IDAHO: Clearwater Co., Elk River, Aug. 1929, E. E. Hubert (Herb. J. S. B. 2073); Clearwater Nat. For., Bungalow Ranger Station, July 31, 1931, J. R. Hansbrough (Herb. J. R. H. 607); Crystal Creek, Aug. 2, 1934, H. G. Lachmund and J. S. Boyce (Herb. J. S. B. 2325). MONTANA: Glacier Nat. Park, Aug., 1933, H. E. Bailey (Herb. Univ. California). OREGON: Oregon Caves, Head of Limestone Creek, Aug. 15, 1929, G. D. Darker (Herb. Arnold Arboretum 585). WASHINGTON: Walla Walla Co., Blue Mountain, Aug. 2, 1896, C. V. Piper (Washington Flora 401).

On leaves of *Alnus rhombifolia.* CALIFORNIA: Mendocino Co., May, 1939, H. N. Hansen.

At the time of earlier publication (1939) this fungus was considered to be a variant of *Taphrina robinsoniana.* Ray (1939) has since described it as a separate species. The asci of *Taphrina occidentalis* are somewhat longer and wider, and the stalk cell is wider than in *T. robinsoniana. Taphrina occidentalis* shows the further peculiarity (not reported for *T. robinsoniana*) that the chlamydospore wall breaks to allow emergence of the ascus.

The form on leaves of *Alnus rhombifolia* has stalk cells that are slightly wider and more rounded than in any of the forms on catkins. The ascus emerges from the chlamydospore in the manner typical for this species. It is not impossible that this form on

leaves is a different species but for the time at least it seems best to include it in *Taphrina occidentalis*.

51. *Taphrina viridis* (Sadeb.) Maire

Taphrina viridis (Sadeb.) Maire, Bull. Soc. Bot. France 4e ser. 10:166-176. 1910.
Exoascus viridis Sadebeck (Jaap, Deutsch Bot. Monatschr. 19:75-76. 1901).
Taphrina alnastri Lagerheim, Vestergren Micr. Sel. Exs. 720. 1903.

Causing small, round, pale green or yellow spots (like those produced by *T. sadebeckii*) on leaves of *Alnus viridis* DC.

Mycelium intercellular.

Asci amphigenous, scattered, short-cylindric, or ellipsoidal-oblong, rounded at the apex, stalk cells broad, rounded or truncate below, inserted. Ascospores eight, budding in the ascus, ovate to elliptic. Fig. 22, E.)

Dimensions: Of *asci*, 20-30μ × 7-15μ; of *stalk cells*, 7-13μ × 8-18μ; of *ascospores*, 4.5-5μ × 4-4.5μ.

Distribution: Germany, Austria (Brenner Post, Bad Ratzes), Italian Alps, Scandinavia (according to Saccardo).

Material examined. Germany: Baden, Höllenthal, June 18, 1903, G. Lagerheim (Micr. Sel. Exs. 720. Type of *T. alnastri*); *ibid.*, July, 1903, *id.* (Bot. Mus. Stockholm).

This fungus is very similar to *Taphrina sadebeckii* but, as mentioned above, *Alnus viridis* is clearly not susceptible to attack by the latter fungus, and it seems best to retain the two species as distinct.

HOST INDEX TO SPECIES ON BETULACEAE

Alnus crispa (Ait.) Pursh. var. *mollis* Fern.	*Taphrina tosquinetii* (Westend.) Tul.
Alnus glutinosa Gaertn.	*Taphrina amentorum* (Sadeb.) Rostr. *Taphrina sadebeckii* Johans. *Taphrina tosquinetii* (Westend.) Tul.
Alnus hirsuta Turcz.	*Taphrina amentorum* (Sadeb.) Rostr. *Taphrina sadebeckii* Johans.
Alnus hirsuta Turcz. var. *sibirica* Schneid.	*Taphrina sadebeckii* Johans.
Alnus hybrida A. Br.	*Taphrina amentorum* (Sadeb.) Rostr. *Taphrina tosquinetii* (Westend.) Tul.
Alnus incana Moench.	*Taphrina amentorum* (Sadeb.) Rostr. *Taphrina epiphylla* Sadeb. *Taphrina robinsoniana* Gies.
Alnus incana Moench. var. *aurea* Schelle	*Taphrina epiphylla* Sadeb.
Alnus incana Moench. var. *monstrosa* Winkl.	*Taphrina epiphylla* Sadeb.
Alnus japonica Sieb. and Zucc.	*Taphrina japonica* Kus.
Alnus rhombifolia Nutt.	*Taphrina occidentalis* Ray
Alnus rubra Bong.	*Taphrina amentorum* (Sadeb.) Rostr. *Taphrina japonica* Kus. *Taphrina occidentalis* Ray
Alnus rugosa Spreng.	*Taphrina robinsoniana* Gies. *Taphrina sadebeckii* Johans.
Alnus sinuata Rydb.	*Taphrina occidentalis* Ray
Alnus tenuifolia Nutt.	*Taphrina occidentalis* Ray

Alnus viridis DC.	*Taphrina viridis* Maire
Betula aurata Bechst.	*Taphrina betulina* Rostr.
Betula carpatica Waldst.	*Taphrina betulina* Rostr.
Betula ermani Cham.	*Taphrina betulicola* Nish. *Taphrina nana* Johans.
Betula fontinalis Sarg.	*Taphrina americana* Mix *Taphrina boycei* Mix
Betula fruticosa Pall.	*Taphrina carnea* Johans.
Betula glandulosa Michx.	*Taphrina bacteriosperma* Johans. *Taphrina carnea* Johans.
Betula humilis Schrank.	*Taphrina carnea* Johans.
Betula intermedia Thom.	*Taphrina bacteriosperma* Johans. *Taphrina betulae* (Fkl.) Johans. *Taphrina betulina* Rostr. *Taphrina carnea* Johans. *Taphrina nana* Johans.
Betula japonica Sieb.	*Taphrina nana* Johans.
Betula lutea Michx.	*Taphrina americana* Mix *Taphrina carnea* Johans.
Betula medwediewi Reg.	*Taphrina betulae* (Fkl.) Johans.
Betula nana L.	*Taphrina bacteriosperma* Johans. *Taphrina betulina* Rostr. *Taphrina carnea* Johans. *Taphrina nana* Johans.
Betula occidentalis Hook.	*Taphrina boycei* Mix
Betula papyrifera Marsh.	*Taphrina americana* Mix *Taphrina carnea* Johans. *Taphrina flava* Farl.
Betula pendula Roth.	*Taphrina betulae* (Fkl.) Johans. *Taphrina betulina* Rostr. *Taphrina carnea* Johans. *Taphrina nana* Johans.
Betula populifolia Ait.	*Taphrina flava* Farl.
Betula pubescens Ehrh.	*Taphrina bacteriosperma* Johans. *Taphrina betulae* (Fkl.) Johans. *Taphrina betulina* Rostr. *Taphrina carnea* Johans. *Taphrina nana* Johans.
Carpinus betulus L.	*Taphrina carpini* (Rostr.) Johans.
Carpinus caroliniana Walt.	*Taphrina australis* (Atk.) Gies.
Carpinus orientalis Mill.	*Taphrina carpini* (Rostr.) Johans.
Corylus americana Marsh. *Corylus heterophylla* Fisch. *Corylus rostrata* Ait. *Corylus sieboldiana* Blume	*Taphrina coryli* Nish.
Ostrya carpinifolia Scop.	*Taphrina ostryae* Massal.
Ostrya virginica Willd.	*Taphrina virginica* Sadeb.

IV. SPECIES ON FAGACEAE

Fagus, Nothofagus, Castanopsis, Quercus

Laubert (1928) lists *Taphrina fagi* Lamb., as occurring on *Fagus* sp. in North America. No specimen of such a fungus could be found in the Berlin Museum, whose collection Laubert used in writing his account of known species. When appealed to by letter in 1938 he was unable to recall the source of his information. Thorough search of the literature has yielded no other reference to such a fungus.

52. *Taphrina entomospora* Thaxter

Taphrina entomospora Thaxter, Bot. Gaz. **50**:435. 1910.
Exoascus entomosporus (Thaxt.) Saccardo and Trotter, Sylloge Fungorum **22**:765.
Entomospora antarctica (Sacc.) Jaczewski, Pocket key for the determination of fungi. Part I. Exoascales. Leningrad. 1926.

Causing yellowing (without enlargement or thickening) of leaves of *Nothofagus antarctica* Oerst. All the leaves of a shoot may be attacked.

Mycelium subcuticular.

Asci hypophyllous, subcylindric, rounded or subtruncate at the apex, provided with a stalk cell which is usually broader than the ascus. Ascospores eight, described by Thaxter as bearing appendages of two orders.

Dimensions: Of *asci,* 36-53μ × 10-17μ; of *stalk cells,* 10-13μ × 17-23μ. (Thaxter reports asci 55-60μ × 13-15μ, perhaps including the stalk cell in his measurements); of *ascospores,* 3.5-6μ × 2-4.5μ; of *blastospores,* 10-23μ × 0.5-1.0μ. (Thaxter reports ascospores as 9-10μ × 3-4μ, with terminal appendages 8-12μ × 3-5μ, subterminal appendages 15-25μ × 0.8μ.) (Fig. 23, A.)

Distribution: Patagonia.

Material examined: Chile: Puntas Arenas, Feb., 1906, R. Thaxter (Type).

Perhaps the portion of material examined was not so favorable as that studied by Thaxter. Many asci were old and empty. Only a few appendaged spores were seen, and these were not so beautifully regular as those seen by Thaxter. The appendages looked like narrow elongate buds, and many asci contained numerous filiform blastospores. Most ascospores observed were elliptic, and either lacked appendages or bore one or more short, narrow buds.

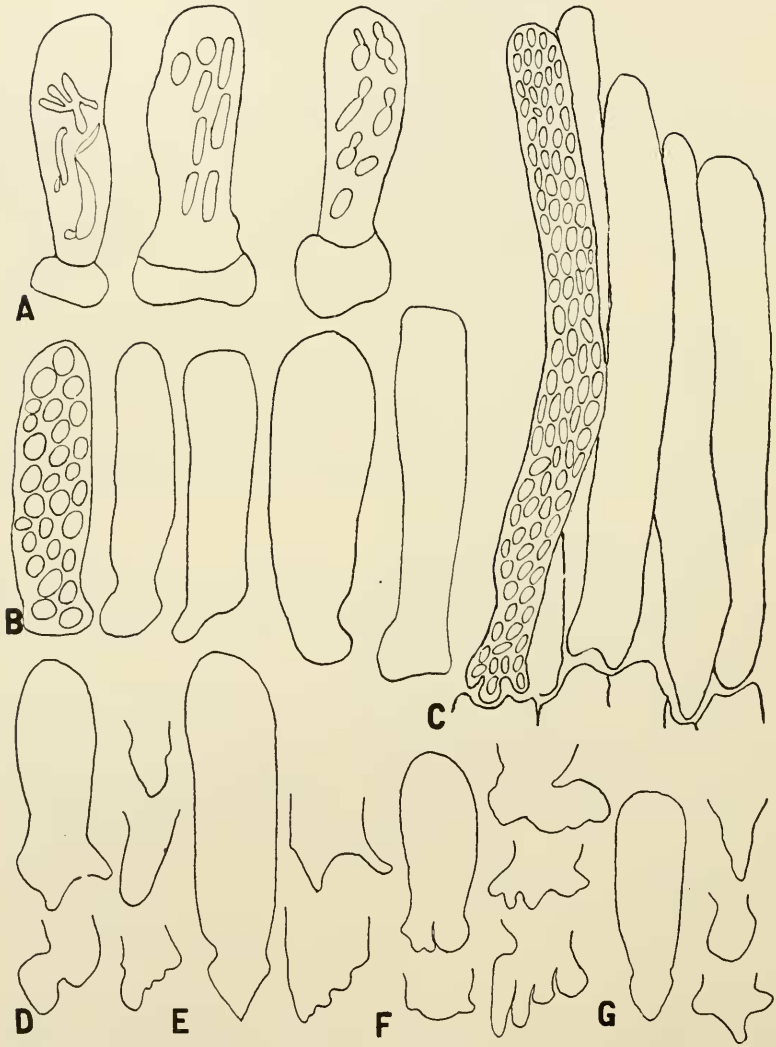

FIG. 23. Asci of A, *Taphrina entomospora;* B, *T. kusanoi;* C, *T. castanopsidis.* D, outlines of asci and ascus-bases of *T. caerulescens* on *Quercus gambelii;* E, *Q. mongolica;* F, *Q. prinoides;* G, *Q. utahensis.* All × 900.

53. *Taphrina castanopsidis* Jenkins

Taphrina castanopsidis Jenkins, Mycologia 28:31-34. 1936.

Causing convex-concave spots on leaves of *Castanopsis chrysophylla* DC.

Mycelium intercellular.

Asci very long, cylindric, narrow, rounded at the apex, narrowed at the base into one or more short rhizoidal extensions, inserted between epidermal cells, no stalk cell present. Ascospores round, eight, budding in the ascus and filling it with smaller ovate to elliptic blastospores.

Dimensions: Of *asci,* 80-165μ × 10-17μ; of *ascospores,* diameter up to 10μ (according to Jenkins); of *blastospores,* 3-5μ × 1.5-2.5μ. (Fig. 23, C.)

Distribution: California.

Material examined: California: Calaveras Co., Dorrington, Aug. 16, 1934, J. S. Boyce (Herb. J. S. B. 2287); region of the upper Sacramento, July 24-Aug. 10, 1894, Sisson (Plants Univ. Calif., 121 Fungi of Calif. as *T. castanicola* E. and E. n. sp.); Siskiyou Co., Mt. Shasta, Aug. 30, 1937, Wm. Bridge Cooke.

54. *Taphrina kusanoi* Ikeno

Taphrina kusanoi Ikeno, Flora 92:1-31. 1903.

Causing small (up to 1 cm. diam.) convex-concave spots on leaves of *Castanopsis cuspidata* Schottky (*Pasania cuspidata* Oerst.).

Mycelium intercellular.

Asci hypophyllous, cylindric, rounded at the apex, often widened at the base, or provided with a distinct foot, lacking a stalk cell. Ascospores not observed, asci filled with round, ovate, or elliptic blastospores, some of them very small. (Fig. 23, B.)

Dimensions: Of *asci,* 36-80μ × 12-20μ (102-117μ × 13-19μ according to Ikeno); of *blastospores,* 2-5μ × 2-3μ or very minute.

Distribution: Japan.

Material examined: Japan: Idzen, Atanei, April 13, 1895; Mt. Tsukuba, May, 1900, Kusano; *ibid.,* June 19, 1929, *id.;* Tokyo, Saginomiya, June 19, 1903, Y. Shibasaksi (Herb. Morioka Imp. Coll. Agric. and For.).

If this species actually possesses asci of the size given by Ikeno, the possibility of its synonymy with *Taphrina castanopsidis* may arise. However, in specimens examined the asci were definitely shorter than those of *T. castanopsidis* and the expanded foot of the ascus is a distinguishing feature.

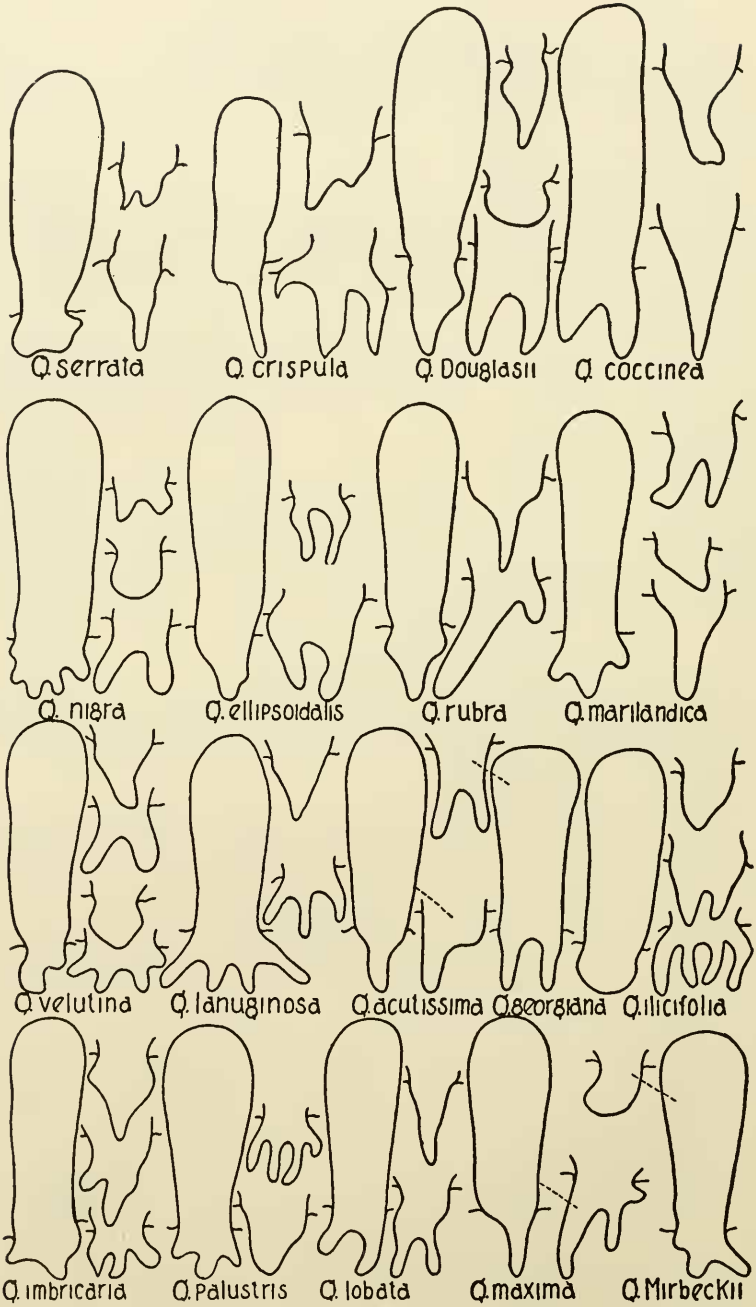

FIG. 24. Asci and ascus-bases (× 900) of *Taphrina caerulescens*, on species of *Quercus*.

55. *Taphrina caerulescens* (Desm.) Tulasne

Taphrina caerulescens (Desm.) Tulasne, Ann. Sci. Nat. 5e Ser. Bot. **5**:122-136. 1866.
Ascomyces caerulescens Desmaziéres, Ann. Sci. Nat. 3e Ser. Bot. **10**:342-361. 1848.
A. alutaceus Thümen, Verhandl. K. K. Zool. Bot. Ges. Wien. **29**:523-524. 1880.
A. extensus Peck, New York State Mus. Nat. Hist. Ann. Rept. **39**:30-70. 1886.
A. rubrobrunneus Peck, New York State Mus. Nat. Hist. Ann. Rept. **40**:39-77. 1887.

Causing small to large, convex-concave, slightly swollen spots or blisters on leaves (occasionally deforming the whole leaf, but not forming true witches' brooms) on many species of *Quercus*. (A complete list, as far as known, is given below.)

Mycelium intercellular.

Asci epiphyllous or hypophyllous, very variable in size and shape, cylindric or clavate, usually rounded at the apex, at the base blunt, rounded, or truncate, and seated or slightly inserted; or else wedge-shaped, pointed, or with rhizoidal appendages, and more or less deeply inserted between epidermal cells. Stalk cells lacking. Ascospores rarely seen, asci filled with round, ovate, or elliptic blastospores. (Fig. 23, D-G, Fig. 24, 25.)

Dimensions of *asci* in microns

Quercus acutissima Carruth	50- 92 × 15-27
Quercus agrifolia Née	46- 68 × 15-19
Quercus alba L.	49-103 × 15-34
Quercus borealis Michx.	46- 76 × 15-30
Quercus cerris L.	30- 72 × 11-23
Quercus cinerea Michx.	42- 68 × 15-23
Quercus coccifera L.	46- 84 × 11-27
Quercus coccinea Muench.	68-118 × 13-30
Quercus crispula Blume	46- 92 × 14-23
Quercus dentata Thunb.	57- 84 × 13-22
Quercus douglasii Hook. and Arn.	65-118 × 19-28
Quercus ellipsoidalis Hill	57-104 × 15-30
Quercus fruticosa Brot.	38- 65 × 11-19
Quercus gambelii Nutt.	53- 83 × 20-27
Quercus geminata Small	75-120 × 15-27
Quercus georgiana Curtis	49- 84 × 19-30
Quercus ilicifolia Wangh.	46- 84 × 15-27
Quercus imbricaria Michx.	49- 91 × 11-30
Quercus kelloggii Newb.	65-106 × 19-27
Quercus laurifolia Michx.	57- 95 × 15-27
Quercus lobata Née	50- 87 × 17-23
Quercus macrocarpa Michx.	38- 76 × 15-27
Quercus marilandica Muench.	53-103 × 11-26
Quercus maxima Ashe	46- 95 × 13-30
Quercus mirbeckii Dur.	46- 84 × 19-27
Quercus mongolica Turcz.	76-109 × 20-26
Quercus nigra L.	60-102 × 19-34
Quercus palustris Moench	58- 84 × 19-27

Quercus phellos L.	46- 76 × 11-19
Quercus prinoides L.	32- 58 × 18-22
Quercus pubescens Willd. (*Q. lanuginose*)	43- 84 × 15-27
Quercus rubra L.	57- 99 × 17-25
Quercus robur L.	50- 84 × 19-25
Quercus serrata Thunb.	64- 92 × 18-30
Quercus sessiliflora Salisb.	46- 72 × 15-27
Quercus stellata Wangh.	57- 80 × 15-27
Quercus undulata Torr.	38- 84 × 15-27
Quercus utahensis Rydb.	40- 73 × 20-27
Quercus velutina Lam.	49- 95 × 15-27
Quercus virginiana Mill.	68- 95 × 15-23

Ascus-size limits for all known host-species: 30-120μ × 11-34μ.

Material examined: Quercus acutissima. JAPAN: Iwate, Mizuyama, July 25, 1927, K. Togashi (Herb. K. T. 2899); *ibid.*, June 16, 1932, *id.* (Herb. Morioka Imp. Coll. Agric. and For.).

Q. agrifolia. CALIFORNIA: Monterey Co., April, 1938, H. Earl Thomas; *ibid.*, June 16, 1932, H. N. Hansen.

Q. alba. MASSACHUSETTS: Waltham, June 20, 1935, D. H. Linder. NEW YORK: Ithaca, 1938, W. W. Ray. VIRGINIA: Victoria, June 9, 1936, S. A. Wingard.

Q. borealis. CONNECTICUT: East Granby, July 4, 1934, H. G. Eno (U. S. D. A. For. Path. 81724). MASSACHUSETTS: Petersham, July 26, 1928, J. S. Boyce (Herb. J. S. B. 2028). MICHIGAN: Huron Co., Sand Point, near Bayport, July 4, 1938, E. A. Bessey. NEW HAMPSHIRE: Conway, June 8, 1921, P. Spaulding (For. Path. 45371). TENNESSEE: Great Smoky Mts., Nat. Park, Rich Mt., June 24, 1934, L. R. Hesler.

Q. cerris. ALGIER: Guide, Kofouri, Sept. 16, R. Maire and M. Pettitmengin (Miss. Bot. Or. 1906). ITALY: Mt. Penice, Vocarezza (Cav. F. Longob. Exs. 73a); Ponte Organasco (Cav. F. Longob. Exs. 73b).

Q. cinerea. NORTH CAROLINA: Aiken, 1878, H. W. Ravenel (Thüm, Myc. Univ. 2065).

Q. coccifera. ALGIER: Marabout de Sidi-Youssef, Bouzaria, May 8, 1913, R. Maire (Myc. Bor. Afr.). FRANCE: Hyères, June 16 (Rab.-Wint. F. Eur. 3537). GREECE: Mt. Ypsili-Keryphi, near monastery Renive, July 12, 1906, R. Maire (Miss. Bot. Or. 240). MOROCCO: Cap Spartel, April 26, 1924, R. Maire (Champ. Afr. Nord. 8403).

Q. coccinea. GEORGIA: Athens, May 14, 1936, J. H. Miller. MICHIGAN: Huron Co., Sand Point, near Bayport, July 4, 1938, E. A. Bessey. NEW YORK: Ithaca, South Hill Marsh, June 26, 1940, A. J. M.

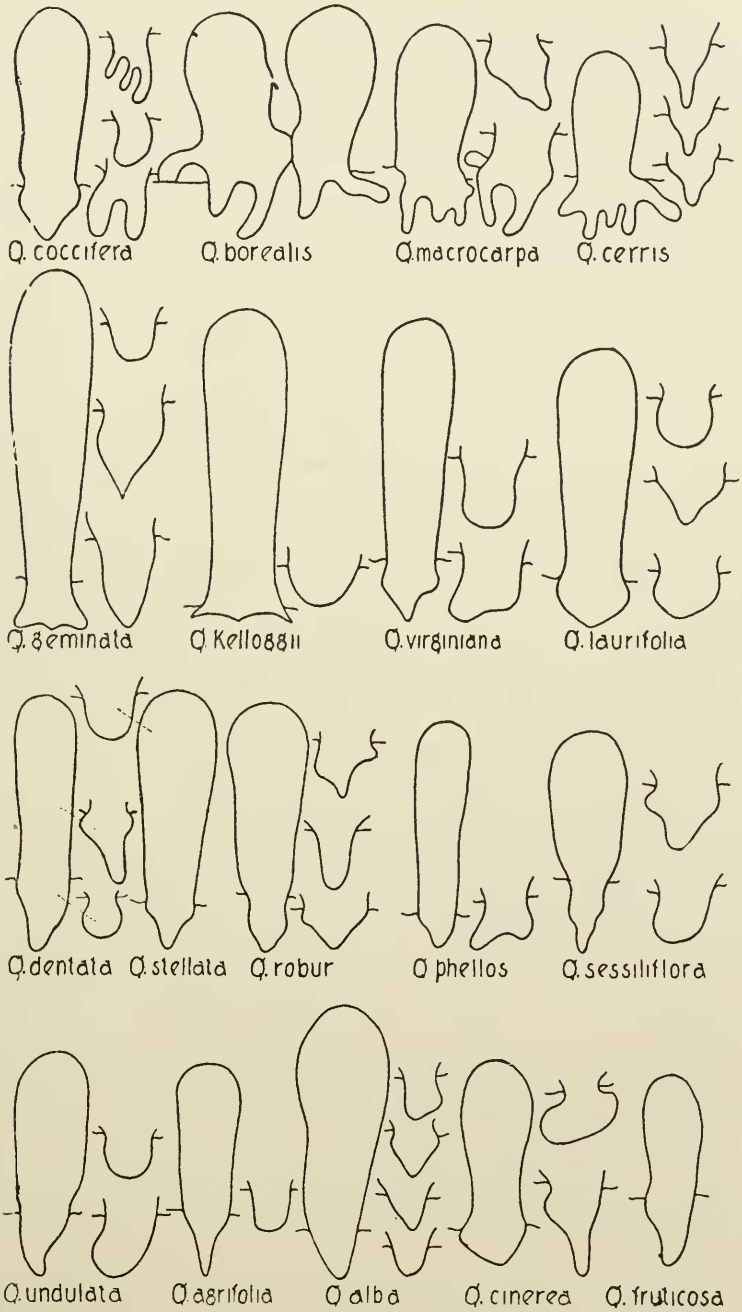

FIG. 25. Asci and ascus bases (×900) of *Taphrina caerulescens*, on species of *Quercus*.

Q. dentata. SASKATCHEWAN: Indian Head, July 25, 1935, B. J. Sollano (Herb. Univ. Toronto).

Q. douglasii. CALIFORNIA: Lake Co., May 3, 1936, H. N. Hansen.

Q. ellipsoidalis. WISCONSIN: Lyndon Station, July 4, 1917, J. J. Davis (Herb. Univ. Wisconsin).

Q. fruticosa. LUSITANIA: Coimbra, summer 1879, A. F. Möller (Myc. Univ. 1553).

Q. gambelii. WYOMING: Medicine Bow Nat. For., Hayden Divn., Sandstone Ranger Sta., July 13, 1939, W. G. Solheim.

Q. geminata. NORTH CAROLINA: May, 1936, R. F. Poole.

Q. georgiana. GEORGIA: Stone Mt., April 26, 1925, J. H. Miller (Herb. Univ. Georgia).

Q. ilicifolia. NEW HAMPSHIRE: W. Ossipee, July 19, 1910, W. G. Farlow (Farl. Herb.). NEW YORK: Sam's Point, Aug., J. Dearness (Herb. J. D.). VIRGINIA: Bald Knob, July, 1918, G. H. Chapman (Herb. Mass. Agric. Coll. 2486).

Q. imbricaria. MISSOURI: Perryvale, C. H. Demetrio (Rab-Pazsch. F. Eur.). NORTH CAROLINA: Greensboro, June, 1934, A. F. Thiel; *ibid.*, spring 1934, E. M. Martin.

Q. kelloggii. CALIFORNIA: Lake Co., May 3, 1936, H. N. Hansen.

Q. laurifolia. FLORIDA: Gainesville, May 20, 1935, G. F. Weber; *ibid.*, April 28, 1941, *id.*

Q. lobata. CALIFORNIA: 1935, H. N. Hansen.

Q. macrocarpa. ALBERTA: J. Dearness (Herb. J. D.). IOWA: W. Okeboji, June 19, 1932, G. W. Martin. KANSAS: Hays, June 6, 1930, E. Bartholomew (N. A. F. 10957, as *T. extensa*); Lawrence, Haskell Meadow, May 14, 1946, A. J. M. WISCONSIN: Granville, July 17, 1867, I. A. Lapham.

Q. marilandica. KANSAS: Baldwin, June, 1933, A. J. M.; *ibid.*, June 2, 1936, *id.*; *ibid.*, May 31, 1937, *id.* MISSOURI: Bagnell Dam, Osage Beach, June 3, 1937, A. J. M.; Seligman, July 12, 1922, R. P. White. VIRGINIA: Princess Anne Co., May 18, 1926, H. T. Cook.

Q. maxima. CONNECTICUT: Collinsville, Aug., 1937, A. J. M.; New Haven, June 23, 1928, *id.*; *ibid.*, June 30, 1928, *id.* GEORGIA: Athens, May 14, 1936, J. H. Miller; Experiment, May 18, 1936, J. L. Weimer. MAINE: Kittery Point, June, 1899, R. Thaxter (Farl. Herb.). MASSACHUSETTS: Amherst, Aug. 19, 1937, A. J. M.; Manchester, Sept. 4, 1928, R. J. Eaton (For. Path. 45878); Sunderland, Aug., 1934, R. H. Thompson. NEW HAMPSHIRE: Canaan, Sept. 23, 1931, E. D. Farnsworth (For. Path. 51682). NEW YORK: Columbia Co., near Hudson, Aug., 1919, A. J. M.; ITHACA: Fall Creek Ravine,

near Beebe Lake, June 27, 1940, *id.;* Poultry Woodlot, Aug. 18, 1929, D. S. Welch (Herb. D. S. W. 819); Klinewoods Road, June 21, 1940, A. J. M.; Sandlake, Sept., 1886, C. H. Peck (*Type* of *T. rubrobrunnea*). Ontario: Muskoka, Muldrew Lake, July 31, 1936, D. S. Welch (Herb. D. S. W. 1286). North Carolina: 1937, J. N. Couch (Herb. Univ. North Carolina, 10724). Tennessee, June 20, 1937, C. D. Sherbakoff. Wisconsin: June 2, 1913, J. J. Davis (Herb. Univ. Wisconsin).

Q. mirbeckii. Morocco: Janger a Agla, April 25, 1924, R. Maire (Champ. Afr. Nord. 8404).

Q. mongolica. Russia: Nyushno-Yssyriiskii Krai, June 13, 1912, N. Naumov (Herb. Sydow).

Q. nigra. Alabama: Auburn, May 8, 1890, G. F. Atkinson (Econ. F. 180). Florida: Gainesville, April 28, 1941, G. F. Weber. Massachusetts: Melrose, June 16, 1936, R. H. Thompson. North Carolina: Durham, F. A. Wolf (Herb. Univ. Tennessee 9978).

Q. palustris. Georgia: Athens, May 14, 1936, J. H. Miller.

Q. pedunculata. Germany: Schleswig-Holstein, Island Sylt, Lornsenhain, near Westerland, May 8, 1911, H. and P. Sydow (Myc. Germ.).

Q. phellos. Alabama: Auburn, May 8, 1890, G. F. Atkinson. North Carolina: 1938, F. A. Wolf.

Q. prinoides. Kansas: Vinland, Violet Hill, May 14, 1946. A. J. Mix.

Q. pubescens. Austria: Kaltenleutgeben, Aug., 1879, Thümen (Myc. Univ. 1554, as *Ascomyces alutaceus*). Italy: Verona, Tregagno, autumn 1906, C. Massalongo (Myc. Ital. Exs. 1678).

Q. robur. Ireland: Glengariff, June 18, 1935, A. J. M.

Q. rubra. Alabama: Auburn, May 13, 1890, G. F. Atkinson (Econ. F. 185). North Carolina: Durham, June, 1935, F. A. Wolf.

Q. sessiliflora. Italy: Florence, Vallombrosa, spring 1898, F. Cavara (Myc. Ital. 534). Montenegro: Savnitz, Sept. 30, 1911, E. Vlack (Bubák Herb.).

Q. stellata. Illinois: Mount Vernon, Aug. 6, 1937, G. H. Boewe. South Carolina: Clemson College, June 15, 1935.

Q. undulata. Colorado: Mancos, June 22, 1898, Baker, Earle and Tracy (Farl. Herb.); Ouray, July 4, 1907, Clements (Crypt. Form Colo. 527).

Q. utahensis. Colorado: Glenwood Springs, Aug. 20, 1941, A. J. M.

Q. velutina. ARKANSAS: Fayetteville, May 21, 1935, J. C. Dunegan. CONNECTICUT: Collinsville, Aug. 17, 1937, A. J. M.; New Haven, June 24, 1928, *id.;* New London, June, 1886, W. G. Farlow (Farl. Herb.). MASSACHUSETTS: Hamilton, July, 1927, P. Spaulding (For Path. 16130); Middlesex Fells, A. B. Seymour; Pigeon Cove, July 28, 1890, *id.* (Econ. F. 184b). MISSISSIPPI: Starkville, May 10, 1890, S. M. Tracy (Econ. F. 184a). MISSOURI: Camdenton, June 3, 1937, A. J. M. WEST VIRGINIA: Monongahela Co., near Lake Lynn, July 12, 1935, C. R. Orton. WISCONSIN: Avoca, July 18, 1923, J. J. Davis (Herb. Univ. Wisconsin).

Q. virginiana. VIRGINIA: Princess Anne Co., May 21, 1935, H. T. Cook; *ibid.,* May 18, 1936, *id.*

Besides the hosts listed above *T. caerulescens* is reported on: *Quercus armeniaca* Kotsch in the Caucasus (Jacsewski); *Q. austrina* Poplarville, Mississippi, Aug. 7, 1925, J. L. Weimer; *Quercus conferta* Kit., Romania (letter from Savelescu, 1939); *Q. gunnisonii,* North Cheyenne Canyon, Colorado, July, 1895, L. H. Pammel.

The above account of *Taphrina caerulescens* is taken from the paper by Mrs. Thompson (1940) with a few emendations and studies of additional species by the writer, and Figures 24 and 25 are copied from her illustrations.

Since the chief point of distinction between *Taphrina caerulescens* and *T. kruchii* (see below) lies in the fact that the latter forms witches' brooms, a collection in the Farlow Herbarium becomes interesting. It is labelled: "Taphrina on red oak, Kittery Point, Maine, June, 1899, Thaxter." Enclosed is a slip of paper with the notation, apparently by Thaxter: "T. kruchii."

The specimens show clusters of diseased leaves arising in some cases from the ends of twigs, in some cases from axillary buds. All leaves are reduced in size and deformed throughout the whole blade. No adventitious buds are present and in spite of their suggestive appearance the structures are not true witches' brooms. The asci conform to those of *Taphrina caerulescens* on *Quercus maxima.*

56. *Taphrina kruchii* (Vuill.) Saccardo

Taphrina kruchii (Vuill.) Saccardo, Sylloge Fungorum **10**:68.
Exoascus kruchii Vuillemin, Rev. Mycol. **13**:141-142. 1892.

Causing pronounced witches' brooms with negatively geotropic curvature of twigs, on *Quercus ilex* L.

Mycelium intercellular.

Asci hypophyllous, cylindric to clavate, rounded at the apex,

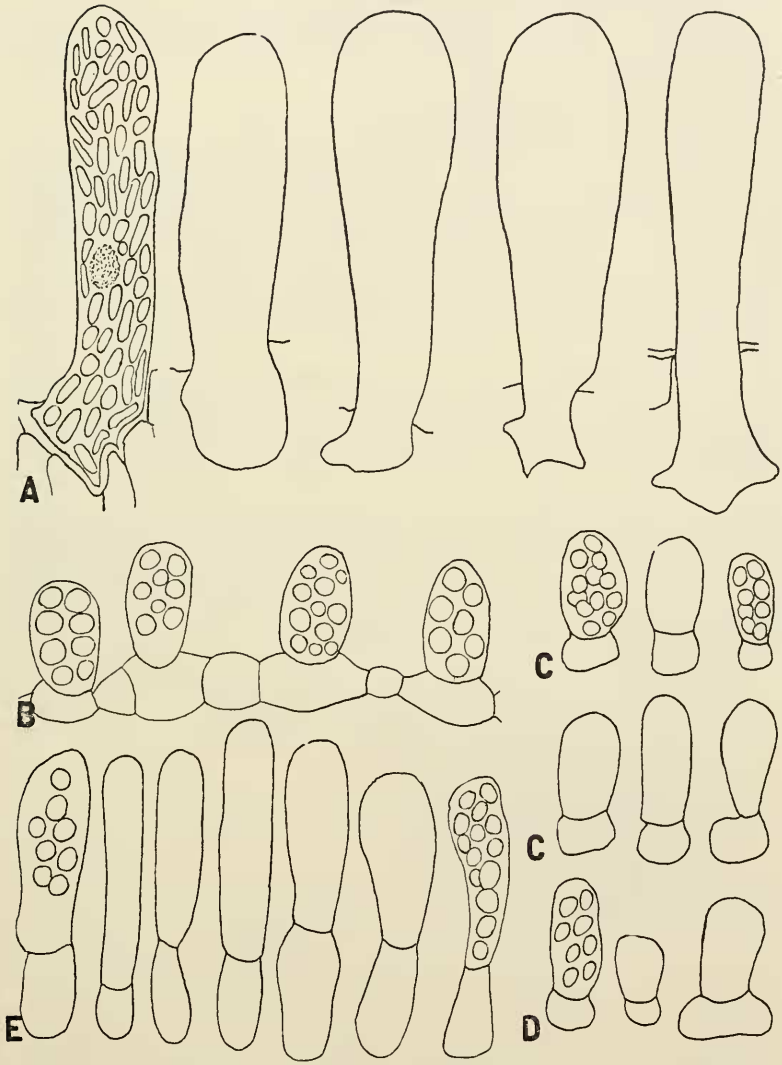

FIG. 26. Asci (×900) of A, *Taphrina kruchii;* B, *T. ulmi;* C, *T. celtis* on *Celtis australis;* D, *C. tournefortii;* E, *Taphrina bullata.*

without stalk cell. Ascospores eight, asci usually filled with elliptic or rod-shaped blastospores. (Fig. 26, A.)

Dimensions: Of *asci,* 40-100μ × 15-25μ; of *ascospores,* 4μ diam. (Vuillemin); of *blastospores,* 2.5μ × 2μ (Vuillemin); of rod-shaped blastospores, 8-10μ × 1.5-2μ.

Distribution: Mediterranean area.

Material examined: ALGIER: between Babor and Tababor, hill "Tizi n' Souk," May 7, 1912, R. Maire (Myc. Bor. Afr. 98, asci not found). CORSICA: Zuza, Sept. 6, 1901, R. Maire (Micr. Rar. Sel. 662). ITALY: Cagliari, Sette Fratella, July, 1900, Cavara (Myc. It. 687). SARDINIA: Mt. Gennargentii, Aug., 1902, A. Firoi (Myc. It. 1517). SICILY: Albano, June 2, 1914, P. Baccoirini (Herb. R. Mus. Florence).

This fungus, whose asci conform to those of *Taphrina caerulescens,* is retained as a separate species because of its habit of forming witches' brooms, and its probable (though unknown) biological specialization.

The specimen (mentioned above) from Albano, Sicily, obtained on loan from the herbarium of the Royal Museum, Florence, is of a large witches' broom with many crowded adventitious shoots. The twigs show negative geotropic curvature, and the leaves are dwarfed and completely deformed by the fungus.

HOST INDEX TO SPECIES OF *TAPHRINA* ON FAGACEAE

(Exclusive of *Taphrina caerulescens*)

Castanopsis chrysophylla DC
    Taphrina castanopsidis Jenkins
Castanopsis cuspidata Schottky
    Taphrina kusanoi Ikeno
Nothofagus antarctica Oerst.
    Taphrina entomospora Thaxt.
Quercus ilex L.
    Taphrina kruchii Vuill.

IV. SPECIES ON URTICACEAE

Ulmus, Celtis

57. *Taphrina ulmi* (Fkl.) Johanson

Taphrina ulmi (Fkl.) Johanson, Ofvers K. Svensk. Vet. Akad. Forhandl. 1885:20-47. 1886.
Exoascus ulmi Fuckel, Jahrb. Nassau. Verein. Naturk. 27 and 28:1-99. 1873 and 1874.
Exoascus campestris Saccardo, Michelia 2:30-135. 1892.

Causing small, yellowish to brown, unthickened or slightly puffed spots on leaves of *Ulmus alata* Michx., *U. americana* L., *U. fulva* Michx., *U. glabra* Huds., *U. laevis* Pall., *U. montana* With., *U. carpinifolia* Gleditsch var. *suberosa* (Moench.) Rehd.

Mycelium subcuticular.

Asci hypophyllous or sometimes epiphyllous, cylindric or ellipsoid, rounded at apex, with a broad stalk cell. Ascospores eight, round, ovate, or elliptic, often budding in the ascus. (Fig. 26, B.)

Dimensions: Of *asci*, 10-29μ × 7-15μ; of *stalk cells*, 6-10μ × 8-22μ; of *ascospores*, 3-6μ × 3-6μ.

Distribution: Europe, North America.

Material examined: Ulmus alata. Alabama: Tuskegee, March 29, 1897, G. W. Carver (Ellis Herb.). Arkansas: near Fayetteville, May, 1941, received by J. C. Dunegan.

U. americana. Quebec: Duchesnay, 1935, R. Pomerleau; *ibid.*, June 12, 1941, *id.*

U. fulva. Kansas: Baldwin, June 15, 1947, A. J. M. Virginia: Blacksburg, June, 1932, S. A. Wingard (U. S. D. A. Path. and Myc. Coll. 66890).

U. glabra. England: Kent, Ivy Hatch, July 10, 1935, A. J. M. Poland: Pulawy, May 20, 1927, W. Siemaszko (Herb. Inst. Phytopath. Schol. Sup. Varsaviensis). Sweden: Uppsala, June, 1885, C. J. Johanson; Skåne, Pelshult, Aug., 1896, G. Lagerheim.

U. laevis. Germany: Saxony, between Schmilka and Herrnskretchen, May 26, 1899, W. Krieger (F. Sax. 622). Holland: Petersberg, near Maastrecht, Aug., 1885, P. Magnus (Rehm. Asco. 869).

58. *Taphrina celtis* Sadebeck

Taphrina celtis Sadebeck, Jahrb. Hamburg. Wissensch. Anst. **8**:61-95. 1890.
Exoascus celtidis (Sadeb.) Saccardo, Sylloge Fungorum **10**:69.
E. aemiliae Passer., Atti. R. Accad. Lincei, Ser. 4, **6**:457-470. "1889" (1890).

Causing small roundish, gray to brown, very slightly thickened spots, apparent on upper surface only, on leaves of *Celtis australis* L., and *C. tournefortii* Lam.

Mycelium subcuticular.

Asci hypophyllous, cylindric to ellipsoid, rounded at the apex; stalk cell flattened, sometimes broader than the ascus. Ascospores eight, round, ovate, or elliptic, often budding in the ascus. (Fig. 26, C, D.)

Dimensions: Of *asci,* 13-28μ × 8-13μ; of *stalk cells,* 7-10μ × 8-13μ (8-10μ × 25-30μ according to Sadebeck); of *ascospores,* 3.5-5μ × 3.5-4.5μ.

Distribution: southern Europe, north Africa.

Material examined. Celtis australis. ALGIER: Sidi-Madani, Gorges de la Cluffa, May 4, 1913, R. Maire (Myc. Bor. Afr. 170). CAUCASUS: Tiflis, Hortus Botanicus, 1911, G. Nevodowski.

C. tournefortii. HERZEGOVINA: Trebinje, May 9, 1897, C. Barinitz (Herb. Sydow).

HOST LIST FOR *TAPHRINA ULMI* (FKL.) JOHANS

Ulmus alata Michx.
Ulmus americana L.
Ulmus carpinifolia Gleditsch var. *suberosa* (Moench.) Rehrd
Ulmus fulva Michx.
Ulmus glabra Huds.
Ulmus laevis Pall.
Ulmus montana With.

V. SPECIES ON ROSACEAE

Pyrus, Sorbus, Amelanchier, Crataegus, Potentilla, Geum

59. *Taphrina bullata* (Berk.) *Tulasne*

Taphrina bullata (Berk.) Tulasne, Ann. Sci. Nat., 5 Ser., Bot. **5**:122-136. 1866.
Ascomyces bullatus Berkeley, Jour. Roy. Hort. Soc. London. **9**:48. 1854.
Exoascus bullatus (Berk.) Sadebeck, Jahrb. Hamburg. Wissensch. Anst. **10**:5-110. 1893.

Causing small, slightly thickened, bullate, irregular brown spots on leaves of *Pyrus communis* L.

Mycelium subcuticular.

Asci hypophyllous, cylindric, rounded or truncate at the apex, stalk cell as broad as, or narrower than the ascus. Ascospores eight, round, ovate, or elliptic, often budding in the ascus (Fig. 26, E.)

Dimensions: Of *asci,* 23-36μ × 8-15μ (30-40μ × 8-9μ according to Sadebeck); of *stalk cells,* 8-17μ × 5-13μ; of *ascospores,* 4.5-5.5μ × 3.5-4.5μ.

Distribution: Europe.

Material examined: Germany: Berlin, Steglitz, Aug. 18, 1887, P. Magnus; Brandenburg, Tamsel Baumschulen, Aug. 26, 1904, P. Vogel (Myc. Germ. 391). Poland: Zalesczyki, May 25, 1910, A. Wróblewski (Myc. Polon. II 54). Sweden: Uppsala: Bot. Gard., June 8, 1912, O. Juel; Stockholm, Experimentalfältet, June 28, 1939, A. J. M.; *ibid.,* July 25, 1939, *id.;* Växtskyddsanstalt, July 1, 1939, *id.;* Tungelsta, July 13, 1939, *id.*

Buhr (1935) reports having seen in the Bremen Botanic Garden *Taphrina bullata* on *Pyrus betulifolia* Bunge, *P. sinensis* Lindl., and "*P. sinensis* × *salicifolia* × *communis.*"

Pyrus sinensis Lindl. is *P. lindleyi* Rehd. and on this host the writer (1947) has described a new species *Taphrina orientalis* (see below). Buhr (l. c.) also states that *T. bullata* occurs at Corte' in Corsica on *P. amygdaliformis* Vill. The fungus is also reported by Tai (1937) as occurring on *P. montana* Nakai, at Port Arthur, Dairen. The report by Rostrup (1890) of *Taphrina bullata* as occurring at Viborg, Denmark, on *Chaenomeles lagenaria* Koidz. (*Cydonia japonica*) is in error. This specimen (obtained on loan from the Copenhagen Museum) is plainly *Pyrus communis,* though perhaps a seedling rather than a cultivated variety.

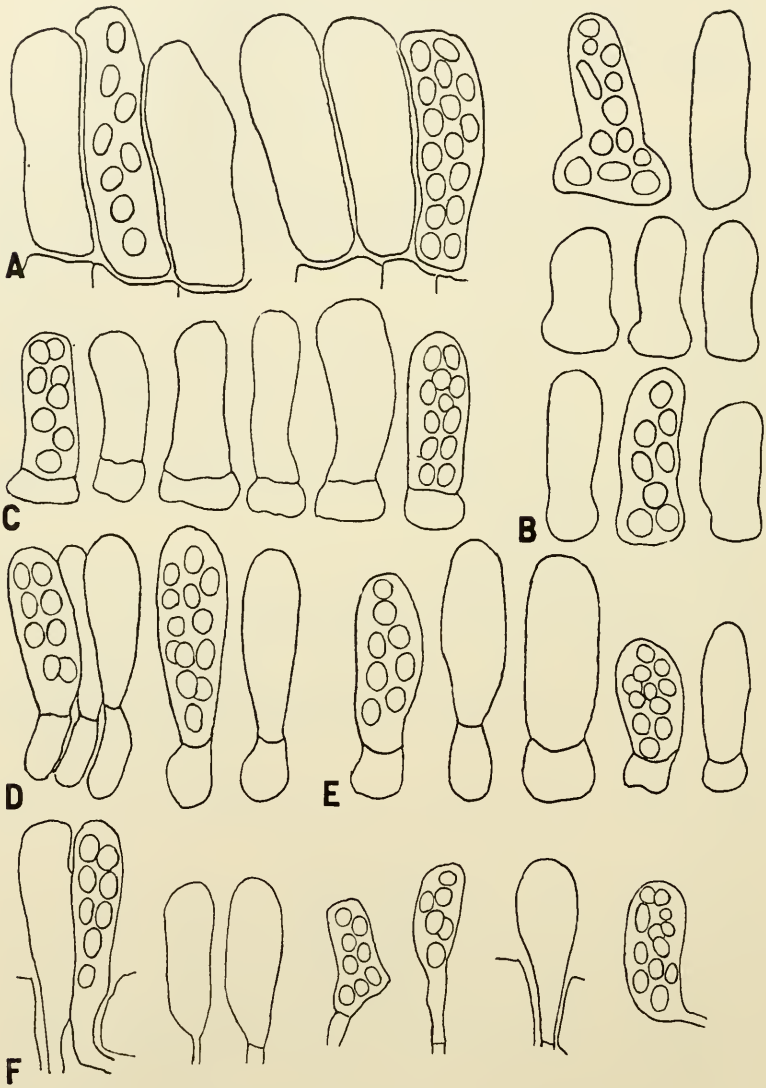

FIG. 27. Asci (× 900) of A, *Taphrina orientalis;* B, *T. piri;* C, *T. sorbi;* D, *T. amelanchieri;* E, *T. crataegi;* F, *T. potentillae.*

60. *Taphrina orientalis* Mix

Taphrina orientalis Mix, Trans. Kansas Acad. Sci. **50**:77-83. 1947.

Causing small (up to 8 mm. diam.) deformed spots on leaves of *Pyrus lindleyi* Rehd.

Mycelium subcuticular.

Asci hypophyllous, cylindric, lacking a stalk cell, seated on the epidermis. Ascospores eight, frequently budding and filling the ascus with blastospores. (Fig. 27, A.)

Dimensions: Of *asci,* 22-46μ × 8-17μ; of *ascospores,* 4-6μ × 4-5μ.

Distribution: Japan.

Material examined: JAPAN: Pref. Iwate, Morioka, May 30, 1908, G. Yamada (Received from K. Togashi.).

61. *Taphrina piri* Kusano

Taphrina piri Kusano, Bot. Mag. Tokyo **19**:1-3. 1905, and Ann. Mycol. **3**:30-31. 1905.
Exoascus piri (Kus.) Saccardo, Sylloge Fungorum **18**:197.

Causing small, pale, bullate spots or larger curled areas on leaves of *Sorbus alnifolia* K. Koch. (*Pyrus miyabei* Sarg.).

Mycelium subcuticular.

Asci hypophyllous, cylindric, rounded or truncate at the apex, occasionally broadened to a foot below; lacking stalk cells, ascospores eight, round, ovate, or elliptic, frequently budding in the ascus. (Fig. 27, B.)

Dimensions: Of *asci,* 23-42μ × 8-13μ; of *ascospores,* 4-6μ × 3.5-5μ.

Distribution: Japan.

Material examined: JAPAN: Nikko, June 10, 1904, S. Kusano (duplicate of type, received from Kusano); *ibid., id.* (in Bot. Mus. Stockholm).

62. *Taphrina sorbi* (Jacz.) Mix

Taphrina sorbi (Jacz.) Mix, Univ. Kansas Sci. Bull. **24**:10:151-176. 1936.
Exoascus sorbi Jaczewski, Pocket Key for Determination of Fungi. Part I Exoascales. Leningrad. 1926.

Causing small deformed spots, or leaf-curl in leaves of *Sorbus torminalis* (L.) Crantz.

Mycelium subcuticular.

Asci amphigenous, cylindric, rounded or truncate at the apex; stalk cells broad, flat, ascospores eight, round, ovate, or elliptic, frequently budding in the ascus. (Fig. 27, C.)

Dimensions: Of *asci,* 20-40μ × 10-13μ; of *stalk cells,* 5-7μ × 10-15μ; of *ascospores,* 4-5μ × 4-4.5μ.

Distribution: Caucasus.

Material examined: RUSSIA: Transcaucasia, Kahetia, 1897, A.

Jaczewski (Herb. Inst. Prot. Plants, Sect. Phytopath. Leningrad. Part of type).

63. *Taphrina amelanchieri* Mix

Taphrina amelanchieri Mix, Amer. Jour. Bot. **26**:44-48. 1939.

Causing witches' brooms on *Amelanchier alnifolia* Nutt.

Mycelium subcuticular.

Asci hypophyllous, cylindric to clavate, rounded at apex; stalk cells variable in size and shape. Ascospores eight, round, ovate, or elliptic, frequently budding in the ascus. (Fig. 27, D.)

Dimensions: Of *asci*, 20-34μ × 8-13μ; of *stalk cells*, 8-13μ × 6-12μ; of *ascospores*, 3.5-5.5μ × 3-5μ.

Distribution: California.

Material examined: CALIFORNIA: Siskiyou Co., Yreka, near Frenchtown, June 24, 1912, E. P. Meinecke (Type).

64. *Taphrina crataegi* Sadebeck

Taphrina crataegi Sadebeck, Jahrb. Hamburg. Wissensch. Anst. **8**:61-95. 1890.
Exoascus bullatus (Berk.) Fkl., in part. Sadebeck, Jahrb. Hamburg. Wissensch. Anst. **1**:93-124. 1884.
Exoascus crataegi Sadebeck, Jahrb. Hamburg. Wissensch. Anst. **10**:5-110. 1893.

Causing leaf-curl and deforming shoots (not causing true witches' brooms) of *Crataegus monogyna* Jacz., *C. oxyacantha* L., *C. sanguinea* Pall.

Mycelium intercellular.

Asci hypophyllous, cylindric, rounded or truncate at the apex, with stalk cell; ascospores eight, round, ovate, or elliptic, frequently budding in the ascus. (Fig. 27, E.)

Dimensions: Of *asci*, 20-36μ × 8-12μ; of *stalk cells*, 6-13μ × 6-13μ; of *ascospores*, 4-5.5μ × 3.5-4.5μ.

Distribution: Europe.

Material examined: C. monogyna. AUSTRIA: Wienerwald, Hühnerberg near Baden, May, 1904, Höhnel (Rehm, Asco. 1612). POLAND: Krakow, Raciborski (Ex. herb. A. Wróblewski).

C. oxyacantha. GERMANY: Mecklenberg, Kluschenberg near Stargard, June 5, 1907, P. Sydow (Myc. Ger. 593); Saxony, near Leipzig, May, 1884, Pazschke and Winter (Rab.-Wint. F. Eur. 3057.). POLAND: Fredrów, June 20, 1920, A. Wróblewski (Ex. herb. A. Wróblewski).

C. sanguinea. RUSSIA: Smolensk, 1896, A. Jaczewski (Herb. Inst. Prot. Plant Sect. Phytopath. Leningrad).

This fungus, included in *Taphrina bullata* by Fuckel (1873-4), was separated from that form by Sadebeck (1890).

65. *Taphrina potentillae* (Farl.) Johanson

Taphrina potentillae (Farl.) Johanson, Ofvers, K. Svensk. Vetensk. Akad. Forhandl. **1885**:29-47. 1886.
Exoascus deformans (Berk.) Fkl. var. *potentillae* Farlow, N. A. F. 299. Described by Farlow, Proc. Amer. Acad. Arts and Sci. **18**:65-85. 1883.
Taphrina tormentillae Rostrup, Bot. Tidsskr. **14**:230-243. 1885.
Magnusiella potentillae (Farl.) Sadebeck, Jahrb. Hamburg. Wissensch. Anst. **10**:5-110. 1893.

Causing small, whitish to yellowish thickened areas on leaves and stems of *Geum montanum* L., *Potentilla arguta* Pursh., *P. canadensis* L., *P. corsica* Lebem., *P. flabellifolia* Hook., *P. geoides* L., *P. glandulosa* L., *P. recta* L., *P. rupestris* L., *P. silvestris* Neck., *P. tormentilla* Schrk., *P. silvestris* Neck. × *P. procumbens* Sibth., *Potentilla* sp.

Mycelium intercellular.

Asci amphigenous, formed beneath epidermis, clavate, rounded or truncate at the apex, arising from the ends of intercellular hyphae as though borne on a pedicel; ascospores eight, round, ovate, or elliptic, usually budding in the ascus (Fig. 27, F.)

Dimensions: Of *asci*, 17-58μ × 7-17μ; of *ascospores*, 4-5.5μ × 3-4.5μ.

Distribution: Europe, eastern North America.

Material examined: Geum montanum. Corsica: Monte Rotondo, July 22, 1902, R. Maire (Ex. Herb. R. M.).

Potentilla arguta. Connecticut: West Haven, July, 1890, R. Thaxter (Rel. Farl. 644). Michigan: East Lansing, June 29, 1943, E. A. Bessey. Sweden: Uppsala, June 17, 1907, O. Juel.

P. canadensis. Connecticut: New Haven, June 27, 1928, G. P. Clinton; *ibid.*, June 30, 1928, A. J. M. Massachusetts: Wellesley, June 8, 1935, D. H. Linder; *ibid.*, June 22, 1935, *id.* New Jersey: Newfield, Aug., 1894 (F. Columb. 408). Ohio: Warren Co., Foster, May 15, 1937, W. B. Cooke. Tennessee: Elkmont, June 8, 1937, L. R. Hesler. Vermont: Griffith Shelter, Aug. 10, 1936, R. H. Thompson.

P. corsica. Corsica: Coscione near Grienza, June 7, 1901, R. Maire (ex. herb. R. Maire).

P. flabellifolia. California: Mt. Shasta, South Gate Springs, July 10, 1947, Wm. Bridge Cooke (Herb. W. B. C. 20282).

P. geoides. Sweden: Uppsala, Bot. Gard., June 17, 1907, O. Juel; *ibid.*, June 16, 1916, *id.*

P. glandulosa. California: Mt. Shasta, July 5, 1940, W. B. Cooke (Herb. W. B. C. 14626).

P. recta. Sweden: Glanshammar, Skäfsund, Aug. 21, 1925, T. Vestergren.

P. rupestris. GERMANY: Bavaria, Kappellenwiese, near Gerolzhofen, Sept. 17, 1915, A. Vill. (Myc. Ger. 1957). NORWAY: Oslo, Bot. Gard., Aug. 24, 1931, I. Jørstad.

P. silvestris. GERMANY: Brandenburg, Prignitz, Triglitz, Sept. 29, 1898, O. Jaap (F. Sel. Exs. 7). POLAND: Krakow, Raciborski (Ex. herb. A. Wróblewski).

P. procumbens × *silvestris.* GERMANY: Schleswig-Holstein, Föhr. Is., Nieblum, Aug. 1, 1904, O. Jaap (F. Sel. Exs. 7b).

Potentilla sp. (cultiv.). CALIFORNIA: Berkeley, March, 1940, H. N. Hansen.

HOST INDEX TO SPECIES OF *TAPHRINA* ON ROSACEAE, EXCLUSIVE OF *PRUNUS*

Amelanchier alnifolia Nutt.
Taphrina amelanchieri Mix
Crataegus monogyna Jacz.
Taphrina crataegi Sadeb.
Crataegus oxyacantha L.
Taphrina crataegi Sadeb.
Crataegus sanguinea Pall.
Taphrina crataegi Sadeb.
Geum montanum L.
Taphrina potentillae (Farl.) Johans.
Potentilla arguta Pursh.
Taphrina potentillae (Farl.) Johans.
Potentilla canadensis L.
Taphrina potentillae (Farl.) Johans.
Potentilla corsica Lebem.
Taphrina potentillae (Farl.) Johans.
Potentilla flabellifolia Hook.
Taphrina potentillae (Farl.) Johans.
Potentilla geoides L.
Taphrina potentillae (Farl.) Johans.
Potentilla glandulosa L.
Taphrina potentillae (Farl.) Johans.
Potentilla recta L.
Taphrina potentillae (Farl.) Johans.
Potentilla rupestris L.
Taphrina potentillae (Farl.) Johans.
Potentilla silvestris Neck.
Taphrina potentillae (Farl.) Johans.
Potentilla tormentilla Schrk.
Taphrina potentillae (Farl.) Johans.
Pyrus amygdaliformis Vill.
Taphrina bullata (Berk.) Tul.
Pyrus betulifolia Bunge
Taphrina bullata (Berk.) Tul.
Pyrus communis L.
Taphrina bullata (Berk.) Tul.
Pyrus lindleyi Rehd.
Taphrina bullata (Berk.) Tul.
Taphrina orientalis Mix
Sorbus alnifolia K. Koch.
Taphrina piri Kus.
Sorbus torminalis (L.) Crantz.
Taphrina sorbi (Jacz.) Mix

VI. SPECIES ON ROSACEAE

Form on plums: Prunus

66. *Taphrina pruni* Tulasne

Taphrina pruni Tulasne, Ann. Sci. Nat. 5 Ser. Botanique. **5**:122-136. 1866.
Exoascus pruni Fuckel, Jahrb. Nassau Ver. f. Naturk **23** and **24**:1-459. 1869 and 1870.
T. rostrupiana (Sadeb.) Giesenhagen, Flora **81**:267-361. 1895.
E. rostrupianus Sadebeck, Jahrb. Hamburg. Wissensch. Anst. **10**:5-110. 1893.
T. insititiae (Sadeb.) Johanson, Ofvers K. Svensk. Vetensk. Akad. Forhandl. **1885**:29-47. 1886.
E. insititiae Sadebeck, Jahrb. Hamburg. Wissensch. Anst. **1**:93-124. 1884.
T. pruni Tul. var. *divaricata* Jaczewski, Pocket Key for the determination of fungi, Part I. Exoascales, Leningrad. 1926.

Causing deformed fruits ("bladder-plums," "plum pockets") and thickened malformed twigs often bearing curled leaves on *Prunus cerasifera* Ehrh. var. *divaricata* Bailey, *P. domestica* L., *P. insititia* L., *P. spinosa* L., *P. ussuriensis* Koval. and Kost.

Mycelium intercellular.

Asci cylindric-clavate, rounded or truncate at the apex; stalk cell present, sometimes nearly half the length of the ascus. Ascospores eight, round, ovate, or elliptic, commonly budding in the ascus. (Fig. 28, A-F.)

Dimensions: Of *asci*, 17-53μ × 5-17μ; of *stalk cells*, 5-27μ × 4-13μ; of *ascospores*, 4-7μ × 3-6μ.

Distribution: Europe. Japan. (North America?)

Material examined: Prunus cerasifera var. *divaricata.* Russia: Caucasus, Suchum, April 27, 1914, W. Siemaszko; Transcaspia, Kopet-Dagh, Han Ailaion, May 30, 1924, Czerniakowska (det. Jaczewski).

P. domestica. New Jersey: (slide in Atkinson collection). New York: Geneva, July 9, 1935, F. C. Stewart. Manitoba: Winnipeg, July 1, 1935, G. R. Bisby. Japan: Iwate, Tamayama, May 29, 1908, G. Yamada (Herb. Morioka Imp. Coll. Agric. and For.). Sweden: Bohuslän, Ljings, Korskviken, July 15, 1888, A. G. Eliasson; Skåne, Bunkeflo, June 10, 1884, Eriksson (on shoots), Småland, Uråsa, Skye, June 3, 1883, Johanson (on shoots); Södermanland, Allhelgona, Bullersta, June, 1894, G. V. Schotte.

P. insititia (as *Taphrina insititiae*). Denmark: Sjaelland, Kallehave, May 14, 1913, J. Lind (Micr. Rar. Sel. 1744). Germany: Brandenburg, Triglitz in Prignitz, May 22, 1899, O. Jaap (F. Sel. Exs. 51). Hungary: Leutschovia, Locse, June, 1891, V. Greschik (F. Leutschov.).

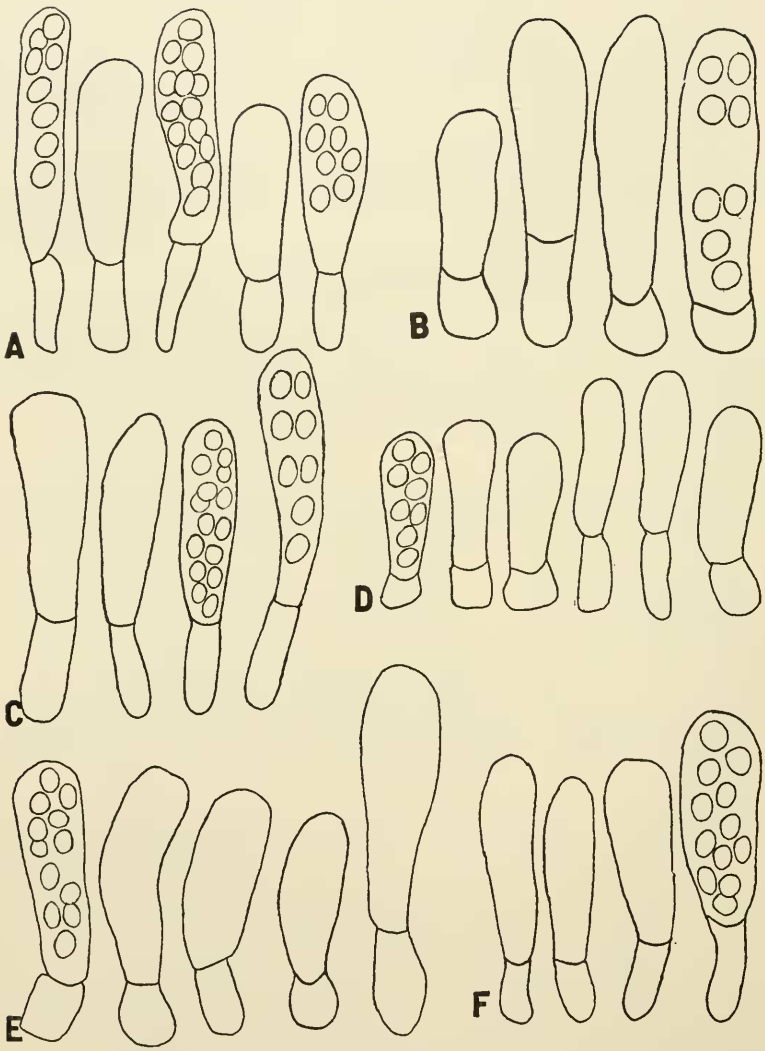

FIG. 28. Asci (×900) of *Taphrina pruni*. A, on *Prunus domestica;* B, *P. cerasifera* var. *divaricata;* C, *P. ussuriensis;* D, *P. domestica,* twigs (as *T. insititiae*); E, *P. spinosa,* twigs; F, *P. spinosa,* fruits (E, F, as *T. rostrupiana*).

P. spinosa (as *T. rostrupiana*). Dalmatia: Cattara, April, 1914, O. Jaap (Ex. herb. Sydow, on both fruits and shoots). Italy: Florence, Vallombrosa, spring 1898, F. Cavara (Myc. Ital. 537). Poland: Pulawy, May, 1923, W. Konopacka (Herb. Inst. Phytopath. Schol. Sup. Varsaviensis). Russia: Nowotscherkassk, May 2, 1911, O. Trebu (shoots). Sweden: Skåne, Kullen, Arild, July 26, 1923, O. Juel (fruits and shoots).

P. ussuriensis. Russia: Nicolsk-Ussurisk, July, 1912, N. Naumov (Herb. Inst. Prot. Plant. Sect. Phytopath. Leningrad).

A portion of a specimen received from R. Maire, labelled: "*Taphrina insititiae*, Graecia, in *Pruno pseudo-armeniaca*, in planitie Kardianos Kambros monelato-vorno inter Lidiki et Amphissam. Balais de sorceres efformat. 14/8 R. Maire" (Miss. Bot. Orient. 1906. 268) was insufficient to allow determination of any fungus present.

Reduction of these various species to synonymy is based on the belief (borne out by observation of several other species of *Taphrina*) that morphologically similar fungi on the fruits and leaves of the same host must be the same. Further there is no clear morphological distinction between different host-forms. The dimensions of the various fungi, considered as separate species, are as follows:

	Asci	*Stalk cells*
T. pruni on fruits of *P. domestica*	23-53μ × 5-13μ	11-27μ × 5-10μ
T. pruni on fruits of *P. cerasifera* var. *divaricata*	26-53μ × 10-17μ	8-23μ × 8-12μ
T. insititiae on shoots of *P. domestica*	17-33μ × 5-10μ	5-10μ × 4-13μ
T. insititiae on shoots of *P. insititia*	17-33μ × 5-10μ	5-10μ × 4-13μ
T. rostrupiana on fruits of *P. spinosa*	26-53μ × 8-16μ	8-20μ × 5-13μ
T. rostrupiana on shoots of *P. spinosa*	23-33μ × 7- 8μ	7-12μ × 6- 8μ

Taphrina insititiae has shorter asci and shorter, and more nearly cuboidal stalk cells (often wider than high) than *T. pruni*. This is the same sort of difference observed in other pruniculous species between the asci formed on fruits and those on leaves. The same difference is to be observed in *Taphrina rostrupiana*, which has been considered to be the same fungus whether occurring on fruits or leaves. There is fairly good agreement in ascus-size between the three fungi under consideration when occurring on fruits.

The frequently noted occurrence of one of these fungi on fruits

only or on shoots only can be explained by the fact that conditions necessary to infection of both fruits and shoots may not occur every season. Magnus (1894) finding plum pockets and malformed shoots on the same tree of *Prunus domestica,* and finding no distinction between the asci from both sources suggested that the same fungus (*T. pruni*) was present on both fruits and twigs.

67. *Taphrina communis* (Sadeb.) Giesenhagen

Taphrina communis (Sadeb.) Giesenhagen, Flora **81**:267-361. 1895.
Exoascus communis Sadebeck, Jahrb. Hamburg. Wissensch. Anst. **10**:5-110. 1893.
T. longpipes (Atk.) Giesenhagen, l.c.
E. longpipes Atkinson, Bull. Torr. Bot. Club. **21**:372-380. 1894.
T. decipiens (Atk.) Giesenhagen, l.c.
E. decipiens Atkinson, l.c.
T. rhizipes (Atk.) Giesenhagen, l.c.
E. rhizipes Atkinson, l.c.
E. decipiens Atk. var. *superficialis* Atkinson, l.c.
T. mirabilis (Atk.) Giesenhagen, l.c.
E. mirabilis Atkinson, l.c.
E. mirabilis Atk. var. *tortilis* Atkinson, l.c.

Causing deformation of fruits ("bladder plums," "plum pockets") and of twigs, sometimes with curling of leaves (not witches' brooms) of *Prunus americana* Marsh., *P. angustifolia* Marsh., *P. hortulana* Bailey, *P. hortulana* Bailey var. *mineri* Bailey, *P. lanata* (Sudw.) Mack. and Bush, *P. maritima* Marsh., *P. munsoniana* Wight and Hedr., *P. nigra* Ait., *P. salicina* Lindl., *P. umbellata* Ell.

Mycelium intercellular.

Asci cylindric-clavate, usually rounded at the apex, stalk cell narrower than the ascus, of variable length, ascospores eight, round, ovate, or elliptic, frequently budding in the ascus.

Dimensions: Of *asci,* 27-83μ × 5-13μ; of *stalk cells,* 6-56μ × 3-12μ; of *ascospores,* 4-7μ × 3.5-5.5μ.

Frequently longer asci occur, projecting above the general surface of the hymenium; these are approximately twice the length of neighboring asci. Such long asci (which are normal in all other respects) may reach a length of 116μ. (Fig. 29, A-F, Fig. 30, A-E.)

Distribution: eastern and middle North America.

Material examined: Prunus americana. ARKANSAS: Conway, May 1, 1939, T. Jones; Fly Gap (near Cass), May 12, 1940, V. H. Young, Mountainburg, May 24, 1941, A. J. M. IOWA: (slides, Atkinson Collection, one on variety Cheney). KANSAS: Abilene, May 22, 1926, H. W. King; Baldwin, May, 1926, A. J. M.; *ibid.,* numerous collections 1925-1939, *id.;* Belpre, June 9, 1924, R. P. White; Lawrence, May 23, 1939, R. Sailer; *ibid.,* K. U. Campus, May, 1942,

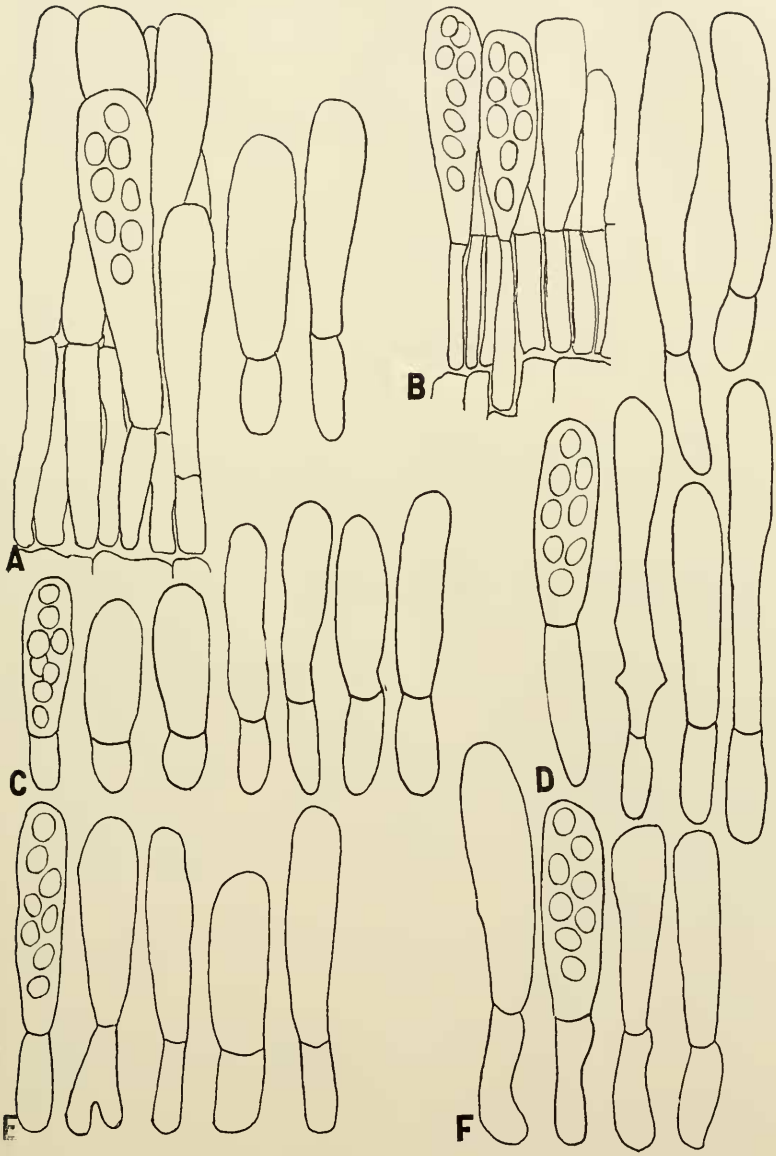

FIG. 29. Asci (× 900) of *Taphrina communis*. A, on *Prunus americana* (fruits); B, *P. umbellata;* C, *P. americana* (twigs); D, *P. maritima* (fruits); E, *P. munsoniana;* F, *P. nigra.*

A. J. M.; Rockport, June, 1894, E. Bartholomew (N. A. F. 298); Rooks Co., May 24, 1901, E. Bartholomew (F. Columb. 1533). MASSACHUSETTS: Morden, June 27, 1929, I. L. Conners. MICHIGAN: Alma, June 2, 1894 (slide in Atkinson Collection); Forest Lake, June 18, 1935, O. J. Eide. NEW YORK: Ithaca, Ellis Hollow Road, June 10, 1940, A. J. M.; *ibid.*, June 22, 1940, *id.* (fruits and shoots); locality not given (slide in Atkinson Collection, on Baldwin variety).

As *T. decipiens.* KANSAS: Baldwin, May, 1927, A. J. M.; Stockton, June 1, 1903, E. Bartholomew (F. Columb. 1927). NEW YORK: Aetna, July 6, 1894 (slide in Atkinson Collection). NORTH CAROLINA: Raleigh, May, 1936, R. F. Poole. SASKATCHEWAN: Indian Head, Aug. 5, 1926, P. M. Simmonds (Herb. Central Expt. Farms. 149).

As *T. decipiens* var. *superficialis.* NEW YORK: Aetna, July 6, 1894 (slide in Atkinson Collection).

As *T. longpipes.* MISSISSIPPI: Grand Rapids, 1898, E. J. Coler (Farl. Herb.). NEW YORK: Danby (slide in Atkinson Collection, from type material).

P. angustifolia, as *T. mirabilis.* ALABAMA: April 28, 1892 (slides in Atkinson Collection); Auburn, April-May, 1890-1892, G. F. Atkinson (Econ. F. 729). ARKANSAS: Fayetteville, May, 1940, V. H. Young; Hamburg, May, 1939, J. C. Dunegan (fruits and shoots). FLORIDA: Gainesville, March 26, 1936, G. F. Weber; *ibid.,* April 9, 1941, *id.* GEORGIA: Athens, May 14, 1936, J. H. Miller. IOWA: Chicasa Co. (slide in Atkinson Collection). KANSAS: 1924, R. P. White; Lawrence, June, 1923, A. J. M.; *ibid.,* several coll. subsequent years, *id.* MISSISSIPPI: Morse, May 21, 1936, L. E. Miles. TENNESSEE: Elkmont, June 13, 1937, L. R. Hesler. VIRGINIA: 1935, S. A. Wingard.

As *T. mirabilis* var. *tortilis.* ALABAMA: (slide in Atkinson Collection). FLORIDA: Gainesville, March 26, 1936, G. F. Weber. KANSAS: 1924, R. P. White.

P. hortulana, as *T. mirabilis.* ARKANSAS: Bentonville, June, 1907, W. A. Scott (Herb. Cornell Univ. 3502). IOWA: Cedar Rapids (slide in Atkinson Collection). WISCONSIN: Blue River, June 9, 1932, J. J. Davis (Farl. Herb.).

P. hortulana var. *mineri.* IOWA: 1894, A. Noe (slide in Atkinson collection).

P. lanata. ARKANSAS: Conway, May 1, 1939, T. Jones.

P. maritima. MASSACHUSETTS: (slide in Atkinson Collection,

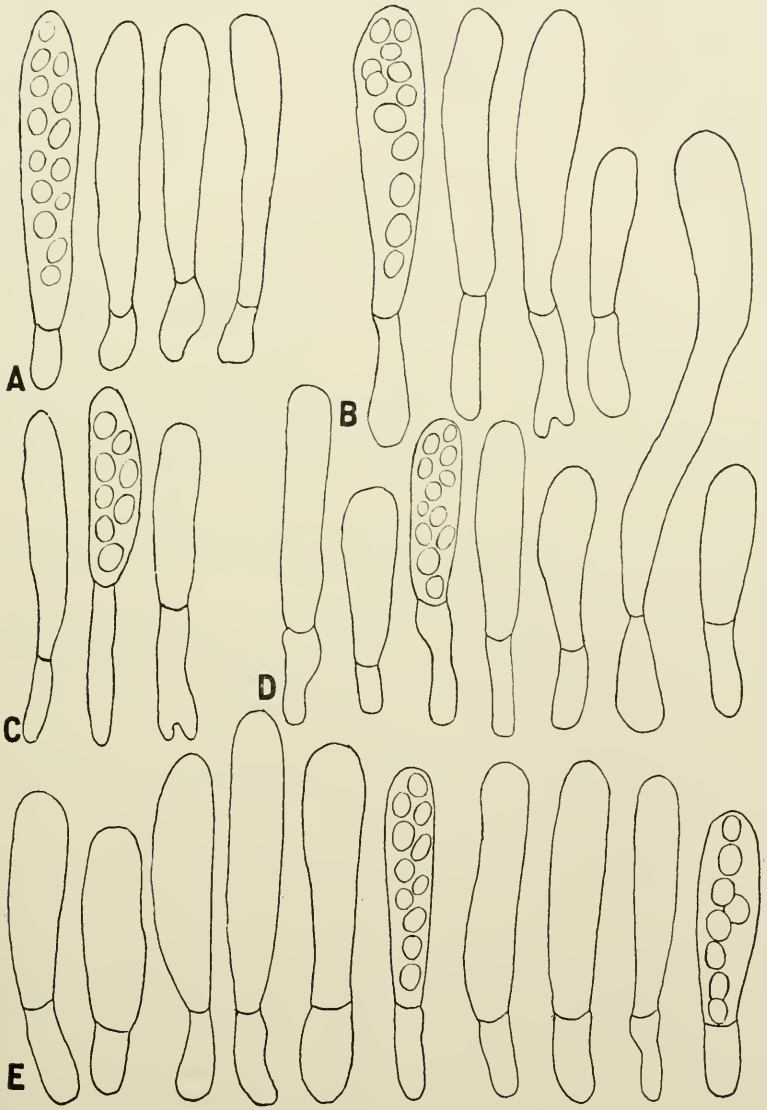

Fig. 30. Asci (× 900) of *Taphrina communis*. A, on *Prunus maritima* (twigs); B, *P. americana* (*T. rhizipes*); C, *P. americana* (*T. longipes*); D, *P. angustifolia* (*T. mirabilis*); E, *P. angustifolia* (*T. mirabilis* var. *tortilis*).

fruits); Barnstable, July 13, 1939, O. C. Boyd (fruits); Cape Cod, June 13, 1939, W. H. Thies and B. Tomlinson (fruits and shoots); Falmouth, June 22, 1940, R. H. Thompson (fruits and shoots); West Falmouth, June 19, 1911, A. B. Seymour (fruits).

P. munsoniana. (Cornell Univ. Herb. 4849, preserved in formalin).

P. nigra. MICHIGAN: St. Johns, June 20, 1938, E. A. Bessey. NEW YORK: Ithaca, Highland Road, June 7, 1940, A. J. Eames; Kline Road, near cemetery, June 7, 1940, A. J. M.; *ibid.*, June 8, 1940, *id.;* Loon Lake, July, 1940, J. R. Stickney. ONTARIO: east of Wilcox Lake, June 14, 1936, R. F. Cain (Herb. Univ. Toronto, 19047). QUEBEC: Aylmer, June 24, 1937, R. K. Eden (Herb. Central Expt. Farms 4614).

P. salicina. ALABAMA: Auburn, May 1, 1892, G. F. Atkinson (apparently type of *T. rhizipes,* both fruit and shoot affected); *ibid.,* May 8, 1892, *id.* (three slides in Atkinson Collection). CONNECTICUT: Cheshire, June, 1891, R. Thaxter (Herb. R. Thaxter 1497).

P. umbellata. GEORGIA: Stone Mountain, April 26, 1925, J. H. Miller (Herb. Univ. Georgia 2475).

As far as Sadebeck (1893) distinguished between *Taphrina communis* and *T. pruni* the former had slightly smaller asci and a longer and narrower stalk cell. Sadebeck's measurements are:

T. pruni, asci 40-55μ × 8-15μ,stalk cells 10-16μ × 8μ.

T. communis, asci 30-40μ × 8μ, stalk cells 15-20μ × 3-5μ.

Actually *T. communis* has longer and slightly more slender asci and stalk cells, the dimensions of the two species being as follows:

T. pruni, asci 17-53μ × 7-17μ, stalk cells 5-27μ × 4-13μ.

T. communis, asci 27-83(116)μ × 5-13μ, stalk cells 7-56μ × 4-10μ.

The chief distinguishing feature of *T. communis* is the occasional occurrence (mentioned above) of very long asci (as long as 116μ). This was observed by Robinson (1887) who spoke of it as "dimorphism," describing long, slender, usually eight-spored asci, 43-60μ × 5-7μ; and shorter, thicker, usually many-spored asci, 27-35μ × 9-12μ. Robinson also states that he found the asci of his "*T. pruni*" more slender than those described by Sadebeck. Although the host is given as *P. domestica* it is apparent that Robinson was dealing with *Taphrina communis.* If his host-determination and those of others who have reported plum pockets on *P. domestica* in North America, are correct it means that *P. domestica* is attacked

by *T. communis*. Apparently it is not highly susceptible. "Domestica" plums are chiefly cultivated in the eastern United States. Plum pockets on cultivated plums have been less commonly reported from that area than from the Mississippi Valley where "Americana" varieties are grown. Assuming that *Taphrina pruni* and *T. communis* are separate species it may be doubted that the former occurs in North America. Plum pockets found on "Domestica" plums in this country should be ascribed to *Taphrina communis*.

The long asci are quite as common in the form described by Atkinson as *Exoascus mirabilis* as in *Taphrina communis* (in the narrower sense). Indeed the former fungus cannot in any way be distinguished from *T. communis*. It deforms shoots of *Prunus angustifolia* and only rarely attacks fruits. This may be due to a less degree of susceptibility of the fruits, or to rarity of conditions necessary for fruit infection. In eastern Kansas, *Prunus angustifolia* seldom bears fruit.

That the fungus on shoots and fruits of *P. angustifolia* are one and the same became clear from a study of the material collected by J. C. Dunegan at Hamburg, Arkansas. The asci were similar on both host organs, those from fruits measuring 33-50μ × 7-10μ with stalk cells 13-23μ × 5-8μ, while asci from shoots were 30-46μ × 7-10μ, stalk cells 13-20μ × 5-8μ. (As in other species asci on shoots are slightly smaller than those on fruits.)

The case for synonymy of *Taphrina communis* and *T. decipiens* has been well presented by Ray (1939) who calls attention to the fact that asci borne on the leaves of infected shoots are somewhat smaller than those found on fruits. Shoot infection is, at least in some localities, less common than fruit infection. In the periods 1926-1929 and 1931-1939 a stand of *Prunus americana* at Baldwin, Kansas, was visited annually. Plum pockets occurred every season but deformed shoots in 1927 only.[7] It is difficult to believe that this single occurrence of malformed shoots in this isolated plum thicket was due to a separate fungus. On the other hand, the idea that conditions favoring shoot infection by the fungus (*T. communis*) known to be present, may occur but rarely is entirely credible. In the more humid climate of the eastern United States (Ithaca, New York, for example) shoot infection seems to be common.

7. The plum thicket in question was not visited for several years after 1939, but in 1947, an unusually rainy spring, shoot infections (as well as pockets) were observed to be abundant in all trees. Deformed fruits and shoots were also observed near Lecompton, Kansas, on May 15, 1947, by R. L. McGregor.

Atkinson (1894) distinguished two other pocket-forming species from *Taphrina communis*, namely: *Exoascus longipes*, and *E. rhizipes*. The first of these was characterized by an unusually long stalk cell. Asci of *T. communis* with stalk cells as long (35μ) as those described by Atkinson for *E. longipes*, are fairly common and have been found in many collections. Because of the variability of *Taphrina communis* from fruit to fruit of the same collection it would be impossible to sort out the various specimens studied into *T. communis* and "*T. longipes*."

Atkinson's *Exoascus rhizipes*, occurring on Japan plum, was characterized by rhizoidal extensions of the lower end of the stalk cell. Such rhizoidal processes occasionally occur in *Taphrina communis* on various hosts and are no more abundant in Atkinson's type material of *E. rhizipes* than in many other collections.

68. *Taphrina pruni-subcordatae* (Zeller) Mix

Taphrina pruni-subcordatae (Zeller) Mix, Univ. of Kansas Sci. Bull. **24**:10: 151-176. 1936.
Exoascus pruni-subcordatae Zeller, Mycologia **19**:130-143. 1927.

Causing deformed fruits (plum pockets) and thickened, malformed shoots on *Prunus subcordata* Benth.

Mycelium intercellular.

Asci clavate, rounded or truncate at the apex, provided with a stalk cell, ascospores eight, round, ovate, or elliptic, often budding in the ascus (Fig. 31, A, B).

Dimensions: Of *asci*, 33-73μ × 7-12μ; of *stalk cells*, 7-40μ × 5-12μ; of *ascospores*, 4-7μ × 3.5-6μ.

Distribution: Rocky-Mountain and Pacific-Coast areas, North America.

Material examined: CALIFORNIA: Cordelia, April 22, 1936, H. Earl Thomas (fruits); Elk Creek, May 15, 1938, *id.* (fruits); *ibid.* (a few miles distant), May 15, 1938, *id.* (shoots); Mt. Shasta, Sept. 6, 1940, W. B. Cooke (Herb. W. B. C. 14724, shoots); Taylorsville, April 23, 1915, J. S. Boyce (Herb. J. S. B. 285, shoots). COLORADO: Boulder, 1942, A. J. M. (fruits and shoots); Fort Collins, 1935, L. W. Durrell (fruits).

This species is closely related to *Taphrina communis*. Its asci are usually somewhat longer and wider and the stalk cells a little shorter than in that species. The exceptionally long occasional asci characteristic of *T. communis* are absent.

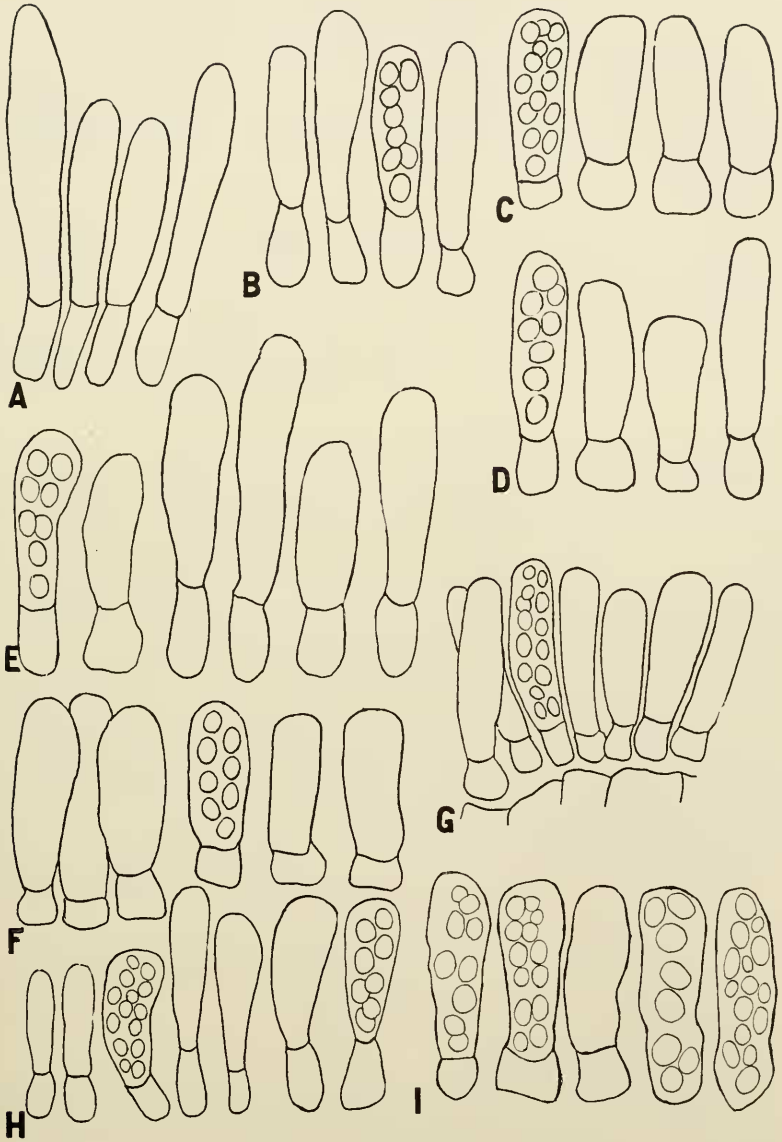

Fig. 31. Asci (× 900) of A, B, *T. pruni-subcordatae* (A, on fruits; B, on twigs); C, D, *T. mume;* E, *T. deformans* on *Prunus communis;* F, G, *T. deformans* on *P. persica;* H, *T. mexicana;* I, *T. armeniacae.*

Forms on Apricots

69. *Taphrina mume* Nishida

Taphrina mume Nishida, Miyabe Festschrift Tokyo, 1911.
Taphrina deformans (Berk.) Fkl. var. *armeniaca* Ikeno, Flora 92:1-31. 1903.

Causing leaf-curl and hypertrophy of twigs of *Prunus armeniaca* L. var. *ansu* Maxim., *P. mandshurica* Koehne, and *P. mume* Sieb. and Zucc.

Mycelium intercellular.

Asci amphigenous or hypophyllous, cylindric, rounded or truncate at the apex, with a broad, short stalk cell; ascospores eight, round, ovate, or elliptic. (Fig. 31, C, D.)

Dimensions: Of *asci,* 20-33μ × 8-13μ (23-52μ × 8-15μ according to Nishida); of *stalk cells,* 7-15μ × 5-15μ; of *ascospores,* 4-6μ × 3-5μ.

Distribution: China, Japan.

Material examined: P. armeniaca. JAPAN: Fukui, Togo-mura, May 18, 1922, T. Toyoda (Herb. Morioka Imp. Coll. Agric. and For.)

P. mume. JAPAN: Hiroshima, May 7, 1930, S. Kusano; Iwate, Morioka, June 23, 1927, K. Togashi (Herb. Morioka Imp. Coll. Agric. and For.); *ibid.,* June 17, 1930, G. Yamada *id.*

This species was considered by Ikeno (1903) and also by Tai (1937) to be a variety of *Taphrina deformans.* It obviously is closely related to *Taphrina deformans,* and if Nishida's measurements are correct, is not morphologically distinguishable from that fungus. Though it is probably identical with *T. deformans,* it is retained as a separate species pending further study.

The occurrence of *Taphrina mume* on *Prunus mandshurica* is reported by Tai. No specimen has been seen by the writer.

70. *Taphrina armeniacae* Georgescu and Badea

Taphrina armeniacae Georgescu and Badea, Analele Institului de Cercetări si Experimentatie Forestură 3:162-167. 1938.

Causing witches' brooms on *Prunus armeniaca* L.

Mycelium intercellular.

Asci amphigenous, cylindric-clavate, rounded or truncate at the apex, a stalk cell usually present but occasionally absent; ascospores eight, round, ovate or elliptic.

Dimensions: Of *asci,* 22-29μ × 7-10μ; of *stalk cells,* 7-10μ × 7-13μ; of *asci lacking stalk cells,* 29-38μ × 8-10μ; of *ascospores,* 4-7μ × 4-6μ. (Fig. 31, I.)

Distribution: Rumania.

Material examined: Twigs and leaves preserved in alcohol, received June, 1947, from Botanical Laboratary, Polytechnic Institute, Bucharest.

Georgescu and Badea state that this fungus causes a witches' broom, with negatively geotropic curvature of twigs. The material studied may well have been from such a witches' broom, but this could not be determined with certainty. The affected leaves are not curled nor conspicuously thickened.

Georgescu and Badea also describe the asci as hypophyllous and lacking a stalk cell. In the material studied asci were regularly amphigenous, and all but a few asci possessed well defined stalk cells. Only by careful search could an occasional ascus lacking a stalk cell be found.

71. *Taphrina deformans* (Berk.) Tulasne

Taphrina deformans (Berk.) Tulasne, Ann. Sci. Nat. 5 Ser. Bot. **5**:122-136. 1866.
Exoascus deformans (Berk.) Fuckel, Jahrb. Nassau. Ver. Naturk. **23** and **24**:1-459. 1869 and 1870.
Ascomyces deformans Berkeley, Outl. Brit. Fungi. 1860.
Taphrina amygdali (Jacz.) Mix, Univ. Kansas Sci. Bull. **24**:**10**:151-176. 1936.
Exoascus amygdali: Jaczewski, Pocket Key for Determination of Fungi. Part I. Exoascales. Leningrad. 1926.

Causing leaf curl and malformation of twigs of *Prunus communis* Arcang. var. *amara Schneid.*, var. *dulcis* Schneid., and *P. persica* L.

Mycelium intercellular.

Asci epiphyllous, occasionally amphigenous, cylindric-clavate, rounded or truncate at the apex, provided with a stalk cell. Ascospores eight, round, ovate, or elliptic, frequently budding in the ascus. (Fig. 31, E, F, G.)

Dimensions: Of *asci*, 17-56μ × 7-15μ; of *stalk cells*, 6-20μ × 5-15μ; of *ascospores*, 3-7μ × 3-7μ.

Distribution: world wide, apparently coincident with that of its hosts.

Material examined: P. persica. California: Berkeley, May 17, 1935, Ruth F. Allen ("ornamental peach"); Palo Alto, April 21, 1939, R. H. Thompson (*P. persica* var. *plena*); *ibid.*, Stanford Univ. orchard, May 23, 1895, S. H. Burnham (nectarine). Illinois: Fayette Co., May 14, 1936, G. H. Boewe; Johnson Co., May 11, 1936, *id.* Kansas: Lawrence, numerous collections 1924-1939, A. J. M. Michigan: Ann Arbor, May 28, 1933, E. B. Mains (Herb. Univ. Michigan). North Carolina: May, 1936, R. F. Poole. Vir-

GINIA: Norfolk, May 6, 1936, H. T. Cook. ONTARIO: London, June, 1892, J. Dearness (F. Columb. 139). CHINA: Kwangsi, Long Ping (Ling Yuin Hsein), April 9, 1933, S. Y. Cheo (Herb. Univ. Nanking). ENGLAND: 1938 (material in alcohol from Royal Coll. of Sci., London). JAPAN: Iwate, Kadoma, June 15, 1931, K. Togashi (Herb. Morioka Imp. Coll. Agric. and For.); Morioka, College Orchard, July 1, 1931; K. Togashi *id.* POLAND: Pulawy, 1923, W. Konopacka (Herb. Inst. Phytopath. Scol. Sup. Agric. Varsaviensis).

P. communis. ENGLAND: specimens in alcohol received from Prof. W. Brown, Royal Coll. of Sci., London. RUSSIA: Caucasus, Derbent, June 10, 1930, A. S. Letov and L. S. Gutner (Herb. Inst. Prot. Plant. Sect. Phytopath. Leningrad). SCOTLAND: Aberdeen, June 19, 1939, Prof. Matthews; St. Andrews, July, 1938, J. A. Macdonald (in alcohol), *ibid.*, June 20, 1939, *id.*

The form on *Prunus communis,* whose occurrence was first recorded by Ráthay (1878), has usually been considered identical with *Taphrina deformans.* Campbell (1925) called it a variety of *T. deformans,* stating that its asci were without stalk cells. In this he was in error. The material received from J. A. Macdonald was collected at St. Andrews from the tree from which Campbell obtained his specimens. This material showed typical asci with stalk cells.

Jaczewski (l. c.) in describing *Exoascus amygdali* stated that it was different from Campbell's fungus (his statement being founded on Campbell's mistaken description). Jaczewski also stated that the asci were regularly hypophyllous. Jaczewski's type material was not obtainable but material that he had examined was received from K. Naumov. In these specimens asci were mostly epiphyllous but occasionally amphigenous.

Cultures were secured in 1939 from the specimens collected by Matthews at Aberdeen, and by Macdonald at St. Andrews. In both cases the material was received in London the day following its collection and isolations were made in the laboratory of Prof. W. Brown of the Royal College of Science.

Using these cultures inoculations of peach were made at Lawrence in the spring of 1947. The trees chosen had been planted in a campus nursery three years previously and had never shown any curl. They were sprayed with 1-50 formalin a few weeks before inoculation. On April 2 during a light rain, inoculum from agar cultures was smeared on opening buds. (Green tips were protrud-

ing about an eighth of an inch from these buds and natural infections of unsprayed trees in the neighborhood had undoubtedly occurred during a rainy period a few days earlier.) Several lower branches of one tree were inoculated with cultures from almond, those of another with cultures from peach. Severe curl resulted in both trees. It appeared later than natural curl on unsprayed trees and asci were not quite mature on May 20, though asci from natural curl had matured as early as May 10. Sprayed but uninoculated branches in the upper parts of these trees remained free from curl.

This indicates that the fungus on *Prunus communis* is not biologically distinct from the form on *P. persica* and that the former should not be distinguished from *Taphrina deformans* either as a separate species or as a variety.

72. *Taphrina mexicana* H. and P. Sydow

Taphrina mexicana H. and P. Sydow, Ann. Mycol. **18**:154-160. 1920.

Causing small witches' brooms on *Prunus microphylla* (HBK) Gray.

Mycelium intercellular.

Asci hypophyllous, clavate, rounded or truncate at the apex, stalk cell usually narrower than the ascus; ascospores eight, round, ovate, or elliptic, small, often budding in the ascus. (Fig. 31, H.)

Dimensions: Of *asci*, 22-30μ × 7-10μ; of *stalk cells*, 8-15μ × 6-8μ; of *ascospores*, 3.5-4μ × 2.5-3.5μ.

Distribution: Mexico.

Material examined: Mexico, 1913, C. Reiche (Bot. Mus. Berlin. Type).

Forms on Cherries: Microcerasus

73. *Taphrina cerasi-microcarpae* (Kuschke) Laubert

Taphrina cerasi-microcarpae (Kuschke) Laubert, in Sorauer, Handb. Pflanzenkr. **2**:457-499. 1928.
Exoascus cerasi-microcarpae Kuschke, Monit. Jard. Bot. Tiflis **31**:23-27. 1913.

Deforming fruits (causing "pockets") of *Prunus microcarpa* C. A. Mey., *P. tomentosa* Thunb. Perhaps also deforming twigs of *P. humilis* Bunge.

Mycelium intercellular.

Asci cylindric-clavate, rounded at the apex, provided with a stalk cell; ascospores eight, round, ovate, or elliptic, frequently budding in the ascus. (Fig. 32, A.)

Dimensions: Of *asci* (*P. microcarpa*), 35-50μ × 10-13μ (Kuschke),

(*P. tomentosa*) 26-46μ × 7-10μ (Mix); of *stalk cells* (*P. microcarpa*) "short" (Kuschke), 5-7μ long (Jaczewski 1926), (*P. tomentosa*) 8-13μ × 7-11μ (Mix); of *ascospores,* 5-7.5μ × 5-6.25μ.

Distribution: Caucasus, Japan, China.

Material examined: P. tomentosa. JAPAN: Ishikari, Hokkaido, June 30, 1902, G. Yamada (Herb. Morioka Imp. Coll. Agric. and For.).

Efforts to obtain a specimen of the fungus on *Prunus microcarpa* from Tiflis or from Leningrad were unsuccessful. It is not known whether a type specimen exists. Some specimens must have been available to Jaczewski (1926). Since the fungus has not been seen the description given above is taken from Kuschke (l. c.) and from Jaczewski (1926).

The fungus on *P. tomentosa* (called by its collector *T. pruni*) is placed here because of its similarity (except for somewhat narrower asci and longer stalk cells) and because the hosts are closely related. For the latter reason the fungus on *P. humilis* reported by Tai (1937) and called by him *Taphrina truncicola* is also tentatively assigned to *T. cerasi-microcarpae.*

74. *Taphrina flavorubra* Ray

Taphrina flavorubra Ray, Mycologia 31:56-75. 1939.

Causing smallish, elongated, pointed "plum pockets," and thickened deformed shoots on *P. besseyi* Bailey, *P. pumila* L., *P. pumila* L. var. *susquehanae* Jaeg.

Mycelium intercellular.

Asci cylindric-clavate, rounded at the apex, provided with a stalk cell; ascospores eight, round, ovate, or elliptic, frequently budding in the ascus. (Fig. 32, B, C).

Dimensions: Of *asci,* 20-53μ × 6-12μ; of *stalk cells,* 8-26μ × 4-10μ; of *ascospores,* 3-8μ × 2-5μ.

Distribution: North America.

Material examined: P. besseyi. KANSAS: Stockton, May 20, 1889, E. Bartholomew (N. A. F. 288). NEBRASKA: Eagle, May 13, 1941, R. W. Goss. OREGON: Corvallis, May 11, 1939, S. M. Zeller. PRINCE EDWARD ISLAND: Little York, Coolhead Road, Mrs. W. J. McDonald (Herb. Central Exp. Farms. 4610).

P. pumila. KANSAS: Rooks Co., 1893, E. Bartholomew (F. Columb. 924). MAINE: Fort Kent, July 1, 1904, M. L. Fernald (Maine Flora, Aroostook County). MICHIGAN: Arenas Co., July 20, 1938, E. A. Bessey. SOUTH DAKOTA: Brookings, June, 1893, Griffiths.

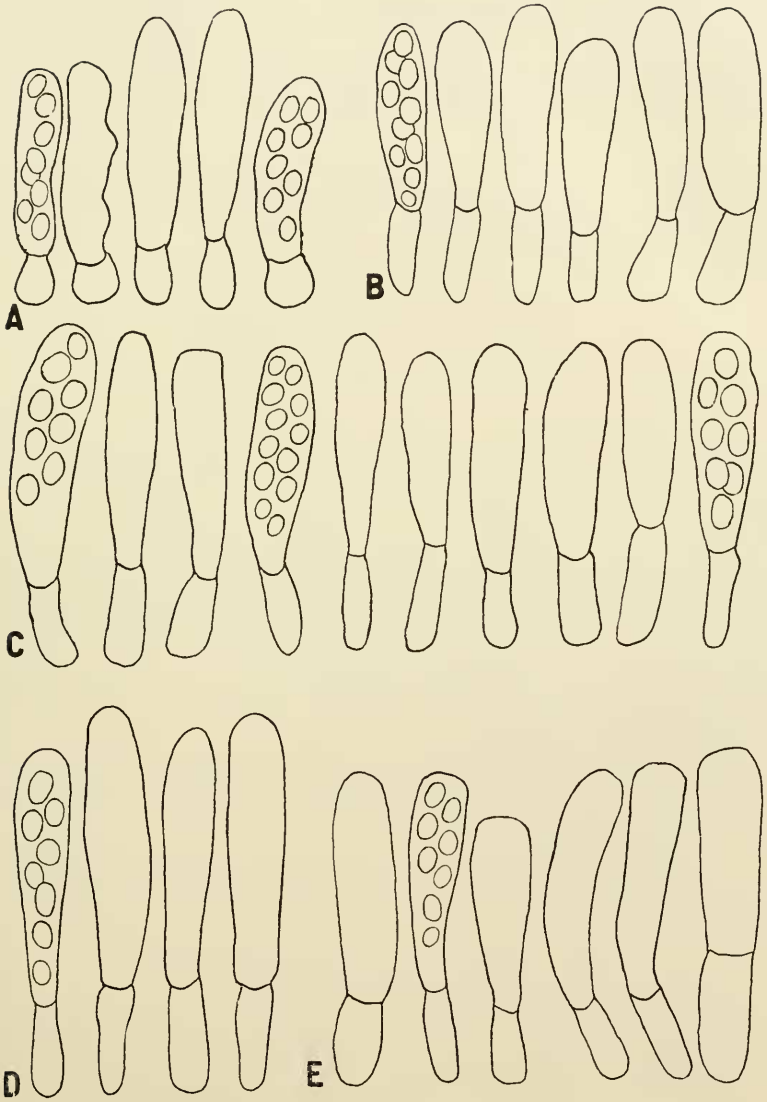

FIG. 32. Asci (× 900) of A, *Taphrina cerasi-microcarpae;* B, C, *T. flavorubra;* B, on *Prunus besseyi;* C, *P. pumila* var. *susquehanae;* D, E, *T. truncicola;* D, on *Prunus incisa;* E, *P. maximowiczii.*

P. pumila var. *susquehanae.* NEW YORK: Ithaca, South Hill Marsh, June 9, 1937, W. W. Ray (Herb. Dept. Plant Path. Cornell Univ. 26425. Fruits. Type); *ibid.*, June, 1940, A. J. M.; *ibid.*, June 1946, *id.* WISCONSIN: Millston, June 9, 1914, W. W. Davis; Necedah, June 9, 1917, *id.* (Herb. Marquette Univ.).

Ray (1939) described this species on *Prunus pumila* L. var. *susquehanae* (Willd.) Jaeg. The fungi on the closely related *P. pumila* L., and *P. besseyi* Bailey agree closely in morphology with *T. flavorubra,* and cause similar host-deformations. It seems proper to assign them to this species.

Forms on Cherries: Pseudocerasus, Lobopetalum, Eucerasus, Mahaleb, and *Phyllomahaleb*

75. *Taphrina truncicola* Kusano

Taphrina truncicola Kusano, Bot. Mag. Tokyo **19**:1-5. 1905.

Causing thickening and malformation of shoots (not witches' brooms) and deformation of inflorescenses of *Prunus incisa* Thunb., and *P. maximowiczii* Rupr.

Mycelium intercellular.

Asci cylindric-clavate, rounded at the apex, provided with a stalk cell. Ascospores eight, round, ovate, or elliptic, frequently budding in the ascus. (Fig. 32, D, E.)

Dimensions: Of *asci,* 30-45μ × 7-13μ; of *stalk cells,* 10-23μ × 5-12μ; of *ascospores,* 4.5-6.5μ × 4-5.5μ.

Distribution: Japan.

Material examined: P. incisa. JAPAN: Iwate, Mt. Iwate, June 18, 1908, G. Yamada (Herb. Morioka Imp. Coll. Agric. and For.); *ibid.,* June 4, 1919, *id.*

P. maximowiczii. JAPAN: Iwate, Mt. Iwate, June 14, 1919, F. Sawada (Herb. Morioka Imp. Coll. Agric. and For.); Nikko, June, 1900, T. Makino.

76. *Taphrina cerasi* (Fkl.) Sadebeck

Taphrina cerasi (Fkl.) Sadebeck, Jahrb. Hamburg. Wissensch. Anst. **8**:61-95. 1890.
Exoascus deformans f. *cerasi* Fuckel, Jahrb. Nassau. Ver. Naturk. **23** and **24**:1-459. 1869 and 1870.
E. cerasi (Fkl.) Sadebeck, Jahrb. Hamburg. Wissensch. Anst. **10**:5-110. 1893.
E. wiesneri Ráthay, Oesterreich Bot. Zeitschr. **30**:225. 1880. (No description.)
T. gilgii Hennings and Lindau, Hedwigia **32**:156-157. 1893.
T. minor Sadebeck, Jahrb. Hamburg. Wissensch. Anst. **8**:61-95. 1890.
E. minor Sadebeck, Jahrb. Hamburg. Wissensch. Anst. **10**:5-110. 1893.
T. pseudocerasi (Shirai) Saccardo, Sylloge Fungorum **14**:824.
Taphria pseudocerasi Shirai, Bot. Mag. Tokyo **9**:161-164. 1895.
E. pruni-acidae Jaczewski, Pockey Key for the determination of fungi. Part I. Exoascales. Leningrad. 1926.

Causing leaf curl (with only slight thickening) and witches' brooms on *Prunus avium* L., *P. cerasus* L., *P. cerasus* L. var. *frutescens* (Neilr.) Schneid. (*P. acida* K. Koch.), *P. fruticosa* Pall., *P. pennsylvanica* L., *P. pseudocerasus* Lindl., *P. serrulata* Lindl. var. *lannesiana* Rehd., and var. *spontanea* Wils., *P. yedoensis* Matsum.

Mycelium intercellular, perennial.

Asci hypophyllous, rarely amphigenous, clavate, rounded at the apex, provided with a stalk cell. Ascospores eight, round, ovate, or elliptic, often budding in the ascus. (Fig. 33, A-F.)

Dimensions: Of *asci*, 17-53μ × 5-15μ; of *stalk cells*, 5-26μ × 4-12μ; of *ascospores*, 3.5-9μ × 3-6μ.

Distribution: Europe, North America, Australia, New Zealand, South Africa, Japan.

Material examined: Prunus avium. California: Berkeley, June 6, 1935, H. Earl Thomas; Napa, April 21, 1929, *id.* New York: Ithaca, Coddington Road, May 27, 1937, W. W. Ray; near R. O. T. C. Stables, May 19, 1938, *id.; ibid.*, May 31, 1940, A. J. M. Oregon: Hood River, May 16, 1936, J. R. Kienholz; Polk Co., June 17, 1935, S. M. Zeller. Washington: Western Washington Exp. Sta. 1935. Czechoslovakia: Prenčŏw, Teplicky, June 20, 1890, A. Kmet (Fungi Schemnitz). England: Gloucestershire, Woodchester Park, May 13, 1934, E. M. Wakefield (Herb. Hort. Bot. Reg. Kew). Germany: Saxony, Putzkau, June 11, 1908, A. Schade (Myc. Germ. 798). Norway: Hordaland, Alsåker in Kinsarvik, June 5, 1929, I. Jørstad. Poland: Pulawy, June, 1923, Z. Czarnocka (Herb. Inst. Phytopath. Sch. Sup. Varsaviensis). Russia: Lublin, Nowo-Alexandria, June 1, 1910, H. Newodowski. Sweden: Uppland, Uppsala, June 2, 1895, A. G. Eliasson.

P. cerasus. British Columbia: Vancouver Island, Coutenay, June 8, 1941, W. S. Jones. Germany: Berlin, Grossbeeren, July, 1893, Lindau and Gilg (Herb. Sydow in Bot. Mus. Stockholm as "forma *Gilgii*"). Lithuania: Kaunas, Aliksotas, May 29, 1936, A. Minkevicius (Herb. Univ. Lithuania). Russia: Kursk, May, 1916, A. Bondarzew (F. Ross. Exs.).

P. cerasus var. *frutescens.* Germany: Berlin, Zehlendorf, May 9, 1911, R. Laubert (type of *T. pruni-acidae*); Saxony, Islebia, June, 1875, J. Kunze (Kunze, F. Sel. Exs. 168 as "*E. deformans* f. *cerasi-acidae*, forma nova").

P. fruticosa (as *T. minor*). Czechoslovakia: Kromau, May, 1913, H. Zimmerman (Fl. Boh. and Mor. Exs. II, 1, 19942). Ger-

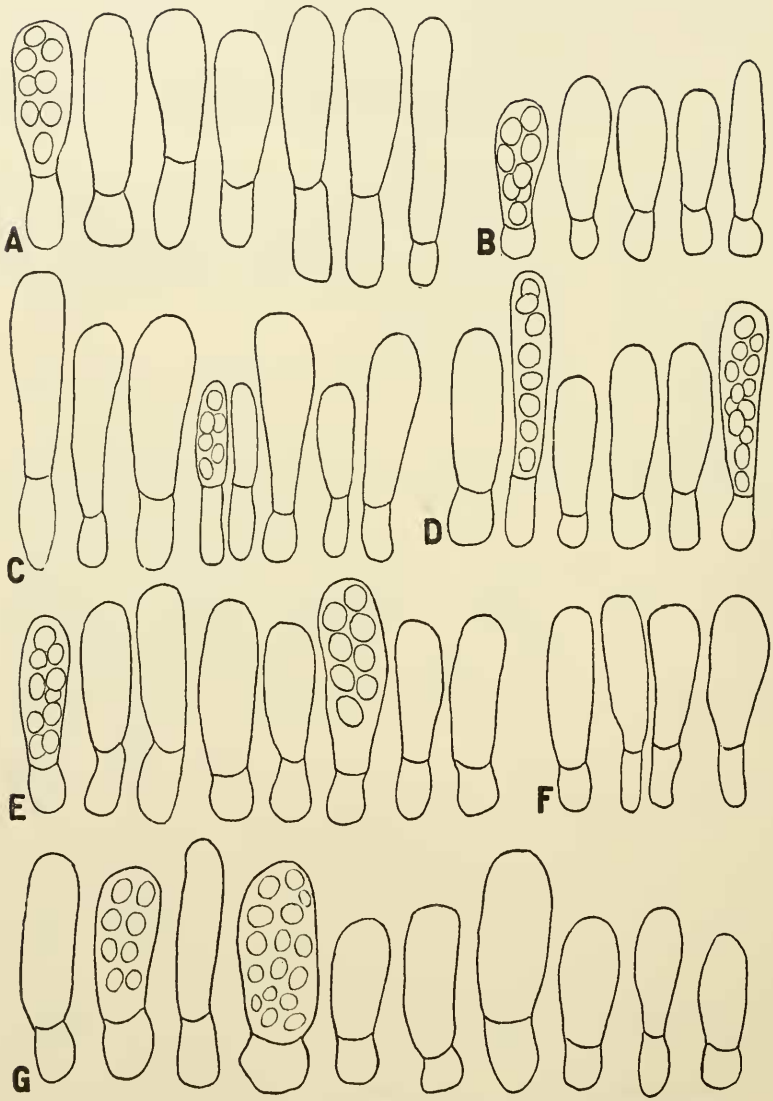

FIG. 33. Asci (× 900) A-F, of *Taphrina cerasi*. A, on *Prunus avium*; B, *P. cerasus*; C, *P. fruticosa* (*T. minor*); D, *P. pennsylvanica*; E, *P. pseudocerasus*; F, *P. yedoensis*; G, asci of *T. flectans*.

many: Hamburg, Winterhude, June 14, 1896, O. Jaap (F. Sel. Exs. 8.). Poland: Skomorochy, 1917, Wróblewski.

P. pennsylvanica. Colorado: Boulder Canyon, El Vado, July 1-2, 1941, A. J. M. Maine: Pembroke, June 9, 1934, J. R. Hansbrough (Herb. For. Path. 81694). Minnesota: Bear River, Big Bear Lake, June 29, 1947, A. J. M. New Hampshire: Cherry Mountains, near Twin Mountain, June 13, 1923, J. S. Boyce (Herb. J. S. B. 1849); Columbia, June 19, 1936, H. G. Eno (Herb. For. Path. 69964); New York: Cranberry Lake, June 12, 1926, P. Spaulding (Herb. For. Path. 16835); Ithaca, Connecticut Hill, June 7, 1940, A. J. M.; near Ringwood, May 28, 1937, W. W. Ray; Watkins Glen, June 6, 1940, A. J. M. North Carolina: Nantahala Gorge, May 29, 1941, A. J. M. Manitoba: Winnipeg, June 25, 1935, G. R. Bisby; east of Beausejour, June 23, 1947, A. J. M. Ontario: Tillsonburg, French Farm, May 19, 1938, P. G. Newell. Quebec: Duchesnay, June 13, 1939, R. Pomerleau.

P. pseudocerasus (as *T. pseudocerasi*). Japan: Ishikari, Sapporo, June, 1902, G. Yamada (Herb. Morioka Imp. Coll. Agric. and For.); Komaba, Coll. of Agric., May, 1900, S. Kusano; Tokyo, May, 1899, Shirai (Herb. Sydow in Bot. Mus. Stockholm).

P. serrulata var. *spontanea* (as *T. pseudocerasi*). Japan: Iwate, Tsunagi, May 17, 1908, G. Yamada (Herb. Morioka Imp. Coll. Agric. and For.); Morioka, Kuroishino, May 25, 1904, G. Yamada (*id.*).

P. yedoensis. Japan: Iwate, Morioka, May 6, 1931, K. Togashi (Herb. Morioka Imp. Coll. Agric. and For.); *ibid.*, May 19, 1934, *id. id.*

The forms here included are alike in size and shape of asci and in size of spores. Spores are seldom of diagnostic value in species of *Taphrina* but the ascospores of *T. cerasi* (and of the related *T. flavorubra*) are exceptionally large.

These fungi occur on closely related host-species, causing on all of them a characteristic leaf curl and on all hosts but two, perennial witches' brooms with clustered twigs showing negatively geotropic curvature.

Taphrina minor on *Prunus fruticosa* (*P. chamaecerasus*) was described by Sadebeck (1890) as causing leaf-curl but no witches' brooms. The fungus described by Laubert (1912) as "*Taphrina* sp." and named by Jaczewski (1926) *Exoascus pruni-acidae* did not cause a witches' broom. It occurred on adventitious shoots arising from roots of *Prunus cerasus*. The host was called by Laubert

P. acida K. Koch, and he stated that it was not the "Glaskirsche" *P. cerasus* var. *acida* Shrk. (*P. cerasus* L. var. *carproniana* L.). Laubert suggests that Sadebeck in describing *Taphrina minor* may have mistaken a wild form of *Prunus cerasus* for *Prunus fruticosa.*

Just who was responsible for first ascribing to *Taphrina minor* leaf curl of *Prunus avium* and *P. cerasus,* distinguishing it from witches' brooms caused by *T. cerasi* on the same hosts, has not been learned, but the practice has become rather common, especially among English authors. In the Farlow Herbarium a collection of *Taphrina cerasi* bears the following in Farlow's handwriting: "*Exoascus minor* Sad. on cultivated cherry, Deal, England, June, 1899. No Hexenbesen. Piece sent to Sadebeck." No letter from Sadebeck later than 1896 could be found among Farlow's correspondence. Sadebeck's opinion on this specimen would have been interesting since he never reported *T. minor* on *Prunus avium* or on *P. cerasus.*

Leaf curl of cultivated cherry is apparently the first stage in the establishment of a witches' broom. It may occur in trees showing no witches' brooms (collection of H. Earl Thomas at Napa, California, 1929) or in trees showing witches' brooms (collection of W. W. Ray at Ithaca, N. Y., 1938).

Why Atkinson (1894) ascribed the fungus on *Prunus pennsylvanica* to *Exoascus insititiae* is hard to understand. That fungus occurs on species of *Prunus* (*P. domestica, P. insititia*) not closely related to *P. pennsylvanica,* and causes twig malformations not at all resembling witches' brooms.

Taphrina pseudocerasi was never a well distinguished species and apparently was not recognized by Nishida (1911), who records *Taphrina cerasi* on *Prunus serrulata* Lindl. var. *spontanea* Maxim., and on *P. subhirtella* Miq. (the hosts for *T. pseudocerasi*).

The morphological similarity of the various host-forms of *Taphrina cerasi* may be seen from the following tabulation.

Taphrina cerasi on:

	Asci	*Stalk cells*
Prunus avium	20-53μ. × 7-15μ.	6-20μ. × 5-10μ.
Prunus cerasus	20-33μ. × 7- 8μ.	7-13μ. × 5- 8μ.
Prunus cerasus var. *frutescens*	20-36μ. × 7-10μ.	8-17μ. × 5- 9μ.
Prunus fruticosa	20-43μ. × 7-12μ.	7-17μ. × 5-10μ.
Prunus pennsylvanica	20-46μ. × 7-13μ.	6-20μ. × 5-10μ.
Prunus pseudocerasus	17-33μ. × 7-10μ.	7-17μ. × 7-10μ.
Prunus serrulata	17-30μ. × 7-13μ.	8-17μ. × 5-10μ.
Prunus yedoensis	20-36μ. × 5-10μ.	5-12μ. × 5-10μ.

It will be seen that the asci and stalk cells are largest on *Prunus avium*, but more specimens of the fungus on this host were examined. Also it is evident that *Taphrina minor* cannot be distinguished from *T. cerasi* by its smaller size, or if so distinguished, *T. minor* should include the form on *P. cerasus* and also the forms on Japanese cherries. (Sadebeck gave as length of asci, for *T. minor* 30-35μ, and for *T. cerasi* 30-50μ.

The occurrence of *Taphrina cerasi* on *Prunus serrulata* var. *lannesiana* is based on the report of Rathbun-Gravatt (1927) who, however, did not actually determine the fungus from this host, but only from *P. yedoensis*.

77. *Taphrina flectans* Mix

Taphrina flectans Mix, Amer. Jour. Bot. **26**:44-48. 1939.

Causing leaf-curl and witches' brooms of *Prunus emarginata* Walp.

Mycelium intercellular, perennial.

Asci hypophyllous, clavate, rounded at the apex, provided with a stalk cell. Ascospores eight, round, ovate, or elliptic, often budding in the ascus. (Fig. 33, G.)

Dimensions: Of *asci*, 20-43μ × 7-12μ; of *stalk cells*, 5-18μ × 5-12μ; of *ascospores*, 4.5-6μ × 4-5μ.

Distribution: Pacific Coast region of North America.

Material examined: California: near Donner Lake, July 13, 1938, H. N. Hansen; Mt. Sanhedrin, Sept. 4, 1939, C. G. Thompson; Mt. Shasta, July 7, 1939, W. B. Cooke (Herb. W. B. C. 13323); *ibid.*, June 16, 1939, *id.* (Herb. W. B. C. 13255); Plumas Co., Gold Lake Lodge, July 31, 1942, Lee Bonar. Idaho: Moscow, June 9, 1935, (received from J. Dearness). Oregon: Oregon Caves, Lake Mountain Trail, Aug. 12, 1929, G. D. Darker.

Much hesitation was felt at the time this fungus was described as a separate species (Mix, 1939). It is morphologically similar to *Taphrina cerasi*, and its ascus-dimensions fall within the size-range observed in that species. Predominantly the asci of *T. flectans* are somewhat shorter and broader. Consistent treatment might call for the inclusion of this form within *Taphrina cerasi* or for the removal of the fungus on *Prunus pennsylvanica* (and of perhaps other host-forms) from *Taphrina cerasi* and erection of a new species therefrom. A knowledge of biological relationships within the group of forms occurring on *Cerasus* would be helpful.

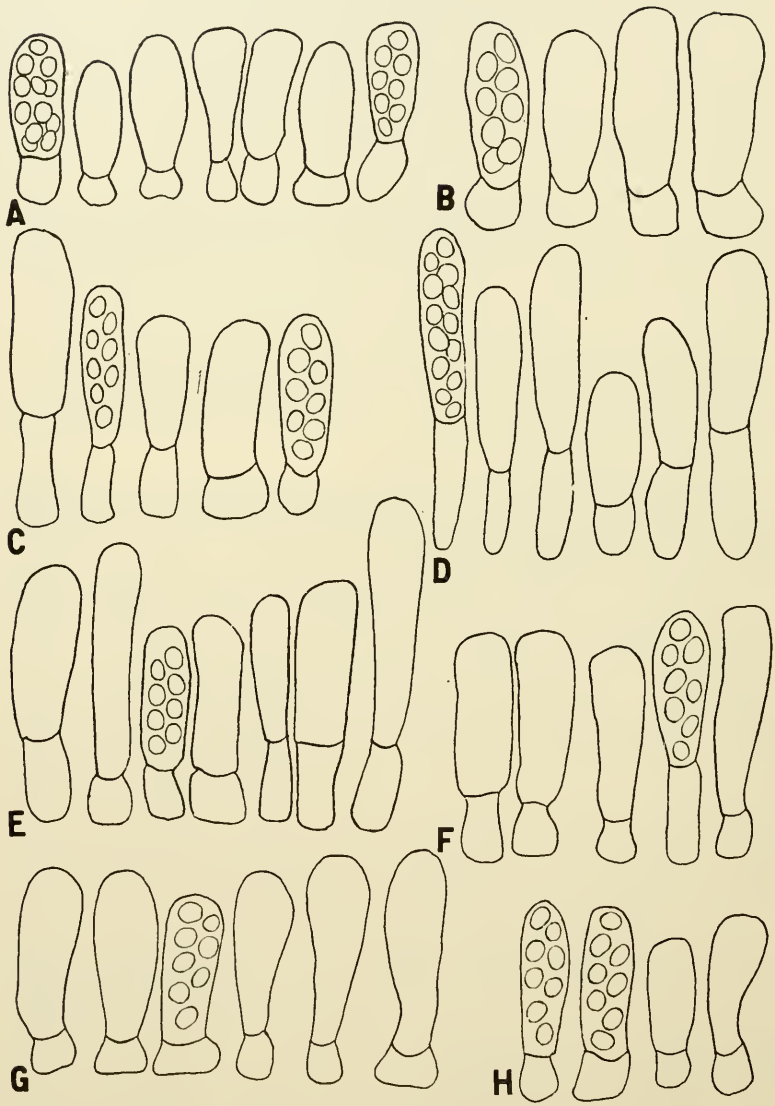

FIG. 34. Asci (× 900) of A, *Taphrina farlowii;* B, C, D, *T. andina,* C, (*T. reichei*), D, on fruits; E-H, *Taphrina confusa,* E, on *P. virginiana,* F, *P. demissa,* G, *P. melanocarpa,* H, *P. alabamensis.*

Forms on Cherries: Padus

78. *Taphrina farlowii* Sadebeck

Taphrina farlowii Sadebeck, Jahrb. Hamburg. Wissensch. Anst. **8**:61-95. 1890.
Exoascus farlowii Sadebeck, Jahrb. Hamburg. Wissensch. Anst. **10**:5-110. 1893.
Taphrina varia (Atk.) Mix, Univ. Kansas Sci. Bull. **24**:10:151-176. 1936.
E. varius Atkinson, Bull. Torr. Bot. Club **21**:372-380. 1894.

Causing leaf curl, thickened, malformed twigs (not witches' brooms), and deformed fruits (pockets) on *Prunus serotina* Ehrh.

Mycelium intercellular.

Asci epiphyllous, or covering surface of fruit, clavate, rounded at the apex, provided with a stalk cell. Ascospores eight, frequently budding in the ascus, round, ovate, or elliptic. (Fig. 34, A.)

Dimensions: Of *asci* on fruits, 13-33μ × 7-13μ, *stalk cells*, 7-13μ × 7-12μ; *asci* on leaves, 13-40μ × 7-13μ; *stalk cells*, 6-13μ × 5-10μ; of *ascospores*, 4.5-6μ × 3.5-5μ.

Distribution: eastern North America.

Material examined: Alabama: Auburn, May, 1891 (Econ. Fungi 128, leaves); *ibid.*, April 29, 1892, slide No. 93 of Atkinson collection (young stem). Arkansas: Fayetteville, April 28, 1938, J. C. Dunegan (leaves, twigs, and fruits). Florida: Gainesville, April 28, 1941, G. F. Weber (leaves). Georgia: Athens, April 22, 1936, J. H. Miller (leaves). North Carolina: Raleigh, May 11, 1936, R. F. Poole (leaves). Vermont: Peru, Stark Monument, July 27, 1927, P. Spaulding (For. Path. 16177, fruits); Smuggler's Notch, June 22, 1927 (For. Path. 16129, leaves). Germany: Charlottenburg, Schlossgarten, Aug. 6, 1891, P. Sydow (Myc. March. 3459, fruits). Locality not given, May 29, 1892, G. F. Atkinson (slide in Atkinson collection, twig).

The identity of the fungus on fruits and shoots is readily seen in the material collected in Arkansas by Dunegan. Not only is the fungus similar on all host-parts, but obviously all the asci arise from the same mycelium.

The occurrence of *Taphrina farlowii* in Germany (Sydow's specimen) must mean that the fungus was introduced with its host.

79. *Taphrina andina* Palm

Taphrina andina Palm, Svensk. Bot. Tidskr. **3**:192-195. 1909.
T. reichei Werdermann, Notizbl. Bot. Gart. and Mus. Berlin-Dahlem. **8**:221-222. 1922.
T. atkinsonii Ray, Mycologia **31**:56-75. 1939.

Causing leaf-curl, witches' brooms, and tremendously elongated (to 6 cm.) fruit-deformations (pockets) on *Prunus serotina* Ehrh. var. *salicifolia* Koehne (*P. capuli* Cav., *P. capollin* Koehne).

Mycelium intercellular.

Asci amphigenous on leaves, also covering fruits and floral parts, cylindric, rounded at the apex, provided with a stalk cell which is variable in length, somewhat narrower than the ascus, and rounded, or truncate and sometimes broadened below. Ascospores eight, round, ovate, or elliptic, often budding in the ascus. (Fig. 34, B, C, D.)

Dimensions: Of *asci*, 23-40μ × 7-13μ; of *stalk cells*, 7-26μ × 5-12μ; of *ascospores*, 4-5.5μ × 3.5-4.5μ.

Distribution: Ecuador, Mexico.

Material examined: ECUADOR: Valle de Chillo, Nov. 13, 1924, F. L. Stevens (Fungi of Ecuador 288, leaves). MEXICO: near City of Mexico, 1920-1921, C. Reiche (Bot. Mus. Berlin, type of *T. reichei*, leaves); Valley of Mexico, June 5, 1896, C. C. Pringle (Farl. Herb., witches' broom); Durango, San Ramon, April 21-May 8, 1906, E. Palmer (Plants of Mexico 173, fruits and floral parts). No locality or date (slide in Atkinson collection).

The type specimen of *Taphrina andina* has apparently been lost. According to Patouillard and Lagerheim (1895) the fungus was collected by Lagerheim who, in giving it to Palm, stated that he had not seen a witches' broom on the host. Palm (1909) makes the lack of a witches' broom his chief reason for distinguishing the fungus from *Taphrina cerasi*. In 1939 no specimen of *T. andina* could be found among Lagerheim's collections at Stockholm's Högskola. The collection by Stevens corresponds well with Palm's description of *T. andina*.

There is no reason for considering the fungus causing leaf curl and witches' brooms as different from that deforming fruits and floral parts. The asci on fruits are longer and narrower (26-40μ × 7-10μ) than on leaves (23-36μ × 8-14μ). Stalk cells from fruits are also longer and narrower (10-26μ × 5-9μ) than those from leaves (7-23μ × 7-12μ). Asci (and stalk cells) on stamens and calyx lobes are intermediate in size. Similar size-differences in asci from leaves and from fruits exist in *Taphrina confusa, T. farlowii, T. communis* and other species.

It is noteworthy that where collection dates are given the fungus on leaves was collected later in the season than on fruits. This is in accord with the writer's experience with *Taphrina confusa* on *P. virginiana* var. *demissa* in Colorado. Leaf curl of this host can be collected long after the diseased fruits and inflorescences have been shed.

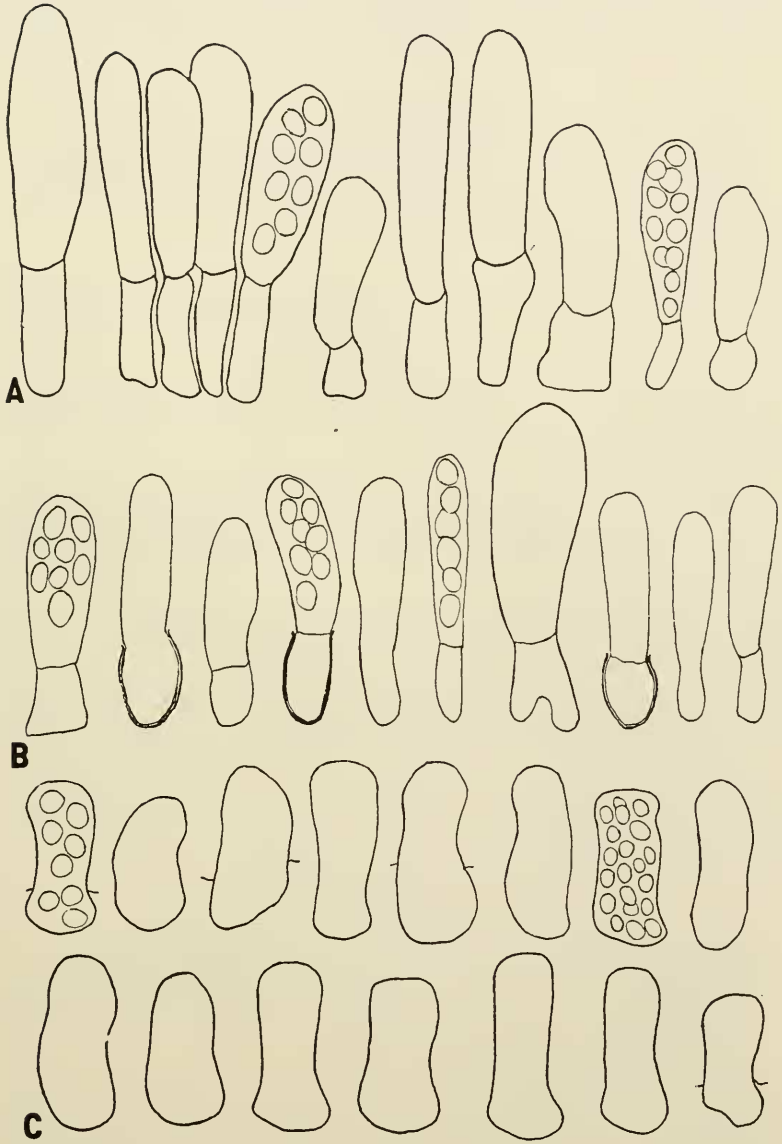

Fig. 35. Asci (× 900) of A, *Taphrina padi;* B, *T. thomasii;* C, *T. purpurascens.*

No asci nor stalk cells as long as those reported by Ray (1939) were seen in this study. A striking feature was the variability in length of the stalk cell in different microscopic mounts, whether from leaves, fruits, or floral parts.

80. *Taphrina padi* (Jacz.) Mix

Taphrina padi (Jacz.) Mix Trans. Kansas Acad. Sci. **50**:77-83. 1947.
T. pruni Tulasne, Ann. Sci. Nat. 5 ser. Bot. **5**:122-136. 1866, in part.
T. pruni Tul. var. *padi* Jaczewski, Pocket Key for the determination of fungi. Part I. Exoascales. Leningrad. 1926.

Causing deformed fruits (pockets) on *Prunus padus* L.

Mycelium intercellular.

Asci clavate, rounded at the apex, stalk cells variable, sometimes widened at the base. Ascospores eight, round, ovate, or elliptic, frequently budding in the ascus. (Fig. 35, A.)

Dimensions: Of *asci,* 26-46μ × 8-13μ; of *stalk cells,* 8-26μ × 7-10μ; of *ascospores,* 5-6μ × 4-5μ.

Distribution: Europe.

Material examined: SWEDEN: Jämtland, Storlien, Aug. 24, 1939, A. J. M.; Lappland, Sulitölma near Lairo, July 29, 1938, T. Arwidsson; Stockholm, Experimentalfältet, July 5, 1939, C. Hammarlund (type).

This fungus has long been considered to be identical with *Taphrina pruni,* though Sadebeck (1893) suggests that the fungi on *Prunus domestica* and *P. padus* may not be the same. Jaczewski (1926) separated the form on *P. padus* as a variety. *Prunus padus* is so distantly related to *P. domestica* and *P. insititia,* that it seems very unlikely that the two fungi are identical. *Taphrina padi* has a distinctive morphology. It is clearly more closely related to *Taphrina farlowii* and to *T. confusa* than to *T. pruni.*

81. *Taphrina confusa* (Atk.) Giesenhagen

Taphrina confusa (Atk.) Giesenhagen, Flora **81**:267-361. 1895.
Exoascus confusus Atkinson, Bull. Torr. Bot. Club **21**:372-380. 1894.
T. unilateralis (Pk.) Mix, Univ. Kansas Sci. Bull. **24**:10:151-176. 1936.
E. unilateralis Peck, New York State Mus. Nat. Hist. Ann. Rept. **51**:267-312. 1898.
T. cecidomophila (Atk.) Giesenhagen, l.c.
E. cecidomophilus Atkinson, l.c.

Deforming fruits and all floral parts of *Prunus alabamensis* Mohr, *P. virginiana* L., *P. virginiana* L. var. *demissa* Torr., and *P. virginiana* L. var. *melanocarpa* Sarg.

Mycelium intercellular.

Asci amphigenous on leaves, also covering surfaces of fruits and floral parts, clavate, rounded at the apex; stalk cells variable in

size and shape, often irregular in outline. Ascospores eight, round, ovate, or elliptic, frequently budding in the ascus. (Fig. 34, E-H).

Dimensions: Of *asci,* 23-53μ × 7-13μ; of *stalk cells,* 6-27μ × 5-13μ; of *ascospores,* 4-7μ × 3.5-6μ.

Distribution: North America.

Material examined: P. alabamensis. Georgia: Pine Mountain, May 12, 1936, J. H. Miller.

P. virginiana. Florida: Gainesville, April 17, 1936, G. F. Weber (leaves). Massachusetts: Cape Cod, Sandwich, June 6, 1937, D. H. Linder (leaves). Michigan: Glen Haven, Day State Park, June 1, 1941, E. A. Bessey (leaves, fruits, and other floral parts). Minnesota: Bear River, Big Bear Lake, June 25, 1947, A. J. M. Nebraska: Dixon Co., Allen, May, 1940, R. W. Goss (leaves); Lincoln, June 3, 1940, L. B. Walker (fruits). New York: Brookton, June, 1904, Fletcher (Cornell Univ. Dept. Plant Path. 20,000, fruits); Etna, June, 1894, G. F. Atkinson (Atkinson Coll. 1192, fruits deformed by insect larvae; apparently type material of *Exoascus cecidomophilus*); *ibid., id.* (two slides in Atkinson Collection, numbered 1192); Evans Mills, June, C. H. Peck ("type No. 1" of *E. unilateralis,* leaves); North Elba, June, 1897, *id.* ("type No. 2" of *E. unilateralis,* leaves); Sempronius, June 5, 1937, W. W. Ray (leaves and fruits); *ibid.,* June 7, 1936, *id.* (fruits and other floral parts). Nova Scotia: Pictou Co., Aug., 1910, I. H. Crowell (fruits). Ontario: London, June, 1893, J. Dearness (N. A. F. 2285, fruits). Finland: near Mustiala, June, 1886, P. A. Karsten (F. Eur. 3473, fruits).

P. virginiana var. *demissa.* California: Berkeley, May 15, 1937, H. Earl Thomas (leaves); Mt. Shasta, Wagon Creek, June 7, 1941, W. B. Cooke (Herb. W. B. C. 15506, leaves, young ovaries, and other floral parts). Colorado: Boulder Canyon, El Vado, July 5, 15, 1943, A. J. M. (leaves); Cross Ruxton, July 5, 1906, F. E. and E. S. Clements (Crypt. Form. Col. 311, leaves); Manitou, Manitou Trail, July 13, 1895, L. H. Pammel (Herb. L. H. P. 114, leaves); Ute Pass, slide No. 97 of Atkinson Collection (fruits). Idaho: Farragut, May, 1944, R. H. Thompson (leaves and inflorescences). Oregon: Eugene, May 30, 1930, J. R. Hansbrough (Herb. J. R. H. 612, leaves). Washington: Klickitat Co., Gulers, May 30, 1920, J. S. Boyce (Herb. J. S. B. 494, leaves); Pullman, June 20, 1893, C. V. Piper (F. Wash. 138, floral parts).

P. virginiana var. *melanocarpa.* Colorado: Fort Collins, June, 1935 (Bot. Dept. Colorado State Coll., leaves). Montana: Madi-

son Co., Madison River Canyon, June 3, 1914, H. M. Jennison (Flor. Mont. 107, leaves).

The case for synonymy of *Taphrina confusa* and *T. unilateralis* has been well presented by Ray (1939). Numerous collections in which leaves, fruits (or ovaries) and other floral parts are affected, and in which the fungus is morphologically similar on all affected parts, leave no doubt as to this synonymy. Peck (1898) gave measurements for *"Exoascus unilateralis"* as: asci, 40-52μ × 13-16μ; stalk cells, 13-16μ broad and "about as long." Examination of Peck's type specimens showed the asci to be 23-30μ × 8-13μ; stalk cells, 8-18μ × 7-10μ. Obviously Peck's measurements are in error.

The fungus on *Prunus alabamensis* with asci measuring 23-34μ × 10-12μ, stalk cells 8-10μ × 9-11μ is intermediate in size between *Taphrina farlowii* and *T. confusa*. It might well have been assigned to *T. farlowii* or called a new species. Its host is apparently more closely related to *P. serotina* than to *P. virginiana*. It is tentatively placed with *Taphrina confusa* because it deforms all floral parts, as does that fungus.

The collection by Piper at Pullman, Washington, is interesting. All floral parts, petals, sepals, stamens, and calyx-cup are enlarged and bear asci, while the ovaries are prolonged into long conical "pockets" 2-3 cm. long, with a curving beak, suggestive of *Taphrina andina* (*T. atkinsonii*).

Forms on Cherries: Laurocerasus

82. *Taphrina thomasii* Mix

Taphrina thomasii Mix, Trans. Kansas Acad. Sci. **50**:77-83. 1947.

Causing witches' brooms on *Prunus ilicifolia* Walp.

Mycelium intercellular.

Asci hypophyllous, cylindric-clavate, rounded at the apex; stalk cell somewhat variable, occasionally forked below, sometimes lacking. Ascospores eight, round, ovate, or elliptic, frequently budding in the ascus. (Fig. 35, B.)

Dimensions: Of *asci,* 20-35μ × 6-10μ (or if stalk cell lacking 32-38μ × 6-10μ); of *stalk cells,* 8-16μ × 6-8μ; of *ascospores,* 4-7μ × 4-5μ.

Distribution: California.

Material examined: CALIFORNIA: Santa Clara Co., Los Altos, 1943, H. Earl Thomas (type); *ibid.,* May 8, 1947, *id.* (co-type).

In this species the stalk cell is cut off late and is sometimes lacking in the mature ascus. The ascus emerges from the chlamydo-

spore, the thicker wall of the latter persisting around the stalk cell or ascus-base.

HOST INDEX TO SPECIES OF *TAPHRINA* ON PRUNUS

Prunus alabamensis Mohr
Taphrina confusa (Atk.) Gies.
Prunus americana Marsh.
Taphrina communis (Sadeb.) Gies.
Prunus angustifolia Marsh.
Taphrina communis (Sadeb.) Gies.
Prunus armeniaca L.
Taphrina armeniacae Georg. and Bad.
Prunus armeniaca L. var. *ansu* Maxim.
Taphrina mume Nish.
Prunus avium L.
Taphrina cerasi (Fkl.) Sadeb.
Prunus besseyi Bailey
Taphrina flavorubra Ray
Prunus cerasifera Ehrh. var. *divaricata* Bailey
Taphrina pruni Tul.
Prunus cerasus L.
Taphrina cerasi (Fkl.) Sadeb.
Prunus cerasus L. var. *frutescens* (Neilr.) Schneid.
Taphrina cerasi (Fkl.) Sadeb.
Prunus communis Arcang. var. *amara* Schneid.
Taphrina deformans (Berk.) Tul.
Prunus communis Arcang, var. *dulcis* Schneid.
Taphrina deformans (Berk.) Tul.
Prunus domestica L.
Taphrina pruni Tul.
Prunus emarginata Walp.
Taphrina flectans Mix
Prunus fruticosa Pall.
Taphrina cerasi (Fkł.) Sadeb.
Prunus hortulana Bailey
Taphrina communis (Sadeb.) Gies.
Prunus hortulana Bailey var. *mineri* Bailey
Taphrina communis (Sadeb.) Gies.
Prunus humilis Bunge
Taphrina cerasi-microcarpae (Kuschke) Laubert
Prunus ilicifolia Walp.
Taphrina thomasii Mix
Prunus incisa Thunb.
Taphrina truncicola Kus.
Prunus insititia L.
Taphrina pruni Tul.
Prunus lanata Mack. and Bush.
Taphrina communis (Sadeb.) Gies.
Prunus mandshurica Koehne
Taphrina mume Nish.
Prunus maritima Marsh.
Taphrina communis (Sadeb.) Gies.
Prunus maximowiczii Rupr.
Taphrina truncicola Kus.
Prunus microcarpa C. A. Mey.
Taphrina cerasi-microcarpae (Kuschke) Laubert
Prunus microphylla (HBK) Gray
Taphrina mexicana H. and P. Syd.
Prunus mume Sieb. and Zucc.
Taphrina mume Nish.

Prunus munsoniana Bailey
Taphrina eommunis (Sadeb.) Gies.
Prunus nigra Ait.
Taphrina communis (Sadeb.) Gies.
Prunus padus L.
Taphrina padi (Jacz.) Mix
Prunus pennsylvanica L.
Taphrina cerasi (Fkl.) Sadeb.
Prunus persica L.
Taphrina deformans (Berk.) Tul.
Prunus pseudocerasus Lindl.
Taphrina cerasi (Fkl.) Sadeb.
Prunus pumila L.
Taphrina flavorubra Ray
Prunus pumila L. var. *susquehanae* Jaeg.
Taphrina flavorubra Ray
Prunus salicina Lindl.
Taphrina eommunis (Sadeb.) Gies.
Prunus serotina Ehrh.
Taphrina farlowii Sadeb.
Prunus serotina Ehrh. var. *salicifolia* Koehne
Taphrina andina Palm
Prunus serrulata Lindl. var. *lannesiana* Rehd.
Taphrina cerasi (Fkl.) Sadeb.
Prunus serrulata Lindl. var. *spontanea* Wils.
Taphrina cerasi (Fkl.) Sadeb.
Prunus spinosa L.
Taphrina pruni Tul.
Prunus subcordata Benth.
Taphrina pruni-subcordatae (Zeller) Mix
Prunus subhirtella Miq.
Taphrina cerasi (Fkl.) Sadeb.
Prunus tomentosa Thunb.
Taphrina cerasi-microcarpae (Kuschke) Laubert
Prunus umbellata Ell.
Taphrina communis (Sadeb.) Gies.
Prunus ussuriensis Koval. and Kost.
Taphrina pruni Tul.
Prunus virginiana L.
Taphrina confusa (Atk.) Gies.
Prunus virginiana L. var. *demissa* Torr.
Taphrina confusa (Atk.) Gies.
Prunus virginiana L. var. *melanocarpa* Sarg.
Taphrina confusa (Atk.) Gies.
Prunus yedoensis Matsum.
Taphrina cerasi (Fkl.) Sadeb.

VII. SPECIES ON ANACARDIACEAE

Rhus

83. *Taphrina purpurascens* Robinson

Taphrina purpurascens Robinson, Ann. Bot. 1:163-176. 1887.
Ascomyces deformans Berk. var. *purpurascens* Ellis and Everhart, North American Fungi No. 1886.

Causing leaf-curl, with great enlargement and reddish-purple coloration of leaves of *Rhus copallina* L., *R. coriaria* L., *R. glabra* L., and *R. typhina* L.

Mycelium intercellular.

Asci hypophyllous or amphigenous, dumbbell-shaped, constricted in the middle, rounded at the apex, rounded or truncate at the base, which is sometimes wider than the apex. No stalk cell. Ascospores eight, frequently budding in the ascus, round, ovate, or elliptic. (Fig. 35, C.)

Dimensions: Of *asci,* 17-40μ × 9-17μ (width of constricted part 6-12μ); of *ascospores,* 3-6μ × 3-5μ.

Distribution: North America, France, Sicily.

Material examined: Rhus coriaria. France: Mountpellier, May 13, 1905, G. Arnaud; *ibid.,* May 21, 1914, *id.*

Rhus copallina. Arkansas: Fayetteville, June 10, 1937; *ibid.,* May 24, 1941, J. C. Dunegan and A. J. M.; Johnson Co., May 13, 1935, W. C. Amstein. Kansas: Neosho Co., 1 mi. E. of Morehead, June 30, 1947, R. L. McGregor; Wilson Co., 3 mi. E. of Neodesha, July 1, 1947, R. L. McGregor; Woodson Co., 3 mi. N. W. of Yates Center, July 1, 1947, R. L. McGregor. Massachusetts: Manchester, July, 1880, W. C. Sturgis (Econ. F. 120a); Pigeon Cove and Magnolia, July 28, 1890, A. B. Seymour (Econ. F. 120b). New Jersey: Newfield, June, 1886, Ellis and Everhart (N. A. F. 1886). Virginia: 1935, S. A. Wingard.

R. glabra. Connecticut: New Haven, R. Thaxter (Farl. Herb. 3661).

R. typhina. Connecticut: New Haven, May, 1889, R. Thaxter; *ibid.,* West Rock, *id.* (Farl. Herb. 1498).

Material was distributed in Fungi Columbiana 4024, as *Exoascus purpurascens* (E. and E.) Sacc. on *Rhus aromatica* Ait., Lake Huron, Ontario, Canada, Aug. 10, 1912, J. Dearness. Several specimens of this collection have been seen and in none of them was a fungus found. The reddish distortions of the leaves appear to be the work of insects.

Montemartini (1940) reports this fungus as occurring on *Rhus coriaria* L. in Sicily.

VIII. SPECIES ON ACERACEAE

Acer.

84. *Taphrina acerina* Eliasson

Taphrina acerina Eliasson, Bih. K. Svensk. Vetensk. Akad. Handl. **20**:3:4: 3-6. 1895.
Exoascus acerinus (Eliass.) Saccardo, Sylloge Fungorum. **14**:823.

Causing leaf-blight and (according to Eliasson) witches' brooms of *Acer platanoides* L. Affected areas on leaves are yellow-brown, watersoaked in appearance (papery when dry), extending from margin in between veins, affecting part or all of the leaf.

Mycelium subcuticular.

Asci amphigenous, broad-cylindric, rounded or truncate at the apex, stalk cell broader than the ascus. Ascospores eight, round, ovate, or elliptic, often budding in the ascus. Ascus emerging from the chlamydospore by rupture of the chlamydospore wall. (Fig. 36, A.)

Dimensions: Of *asci,* 12-23μ × 8-12μ; of *stalk cells,* 7-13μ × 10-20μ; of *ascospores,* 4-5μ × 3.5-5μ.

Distribution: Norway, Sweden, Russia.

Material examined: NORWAY: Anst-Agder, Møglestne in Vestre Moland, June 16, 1932, I. Jørstad. SWEDEN: Uppland, Uppsala, Stafsund, June 28, 1893, A. G. Eliasson; Västergotland, Mariestad, June, 1911, N. Sylven.

85. *Taphrina acericola* Massalongo

Taphrina acericola Massalongo, Malpighia **8**:97-130. 1894.
Exoascus acericolus (Massal.) Saccardo, Sylloge Fungorum **11**:436.
T. jaczewski Palm, Arkiv. Bot. **15**:1-14. 1917.
E. confusus Jaczewski, Bull. Jard. Imp. Bot. St. Petersburg. **1**:7-13. 1901.

Causing small (2-3 mm. diam.), well defined, definitely margined spots, with a tendency toward extension and coalescence, on leaves of *Acer campestre* L.

Mycelium subcuticular.

Asci hypophyllous or amphigenous, short-cylindric to ellipsoid, rounded at the apex; stalk cell short and broader than the ascus; ascospores eight, round, ovate, or elliptic, often budding in the ascus. Ascus emerging from the chlamydospore by rupture of the chlamydospore wall. (Fig. 36, B, C.)

Dimensions: Of *asci,* 16-26μ × 6-13μ; of *stalk cells,* 4-13μ × 8-17μ; of *spores,* 4-5.5μ × 3.5-4.5μ.

Distribution: Italy, Caucasus.

Material examined: As *T. acericola.* ITALY: Spiassi, May 28,

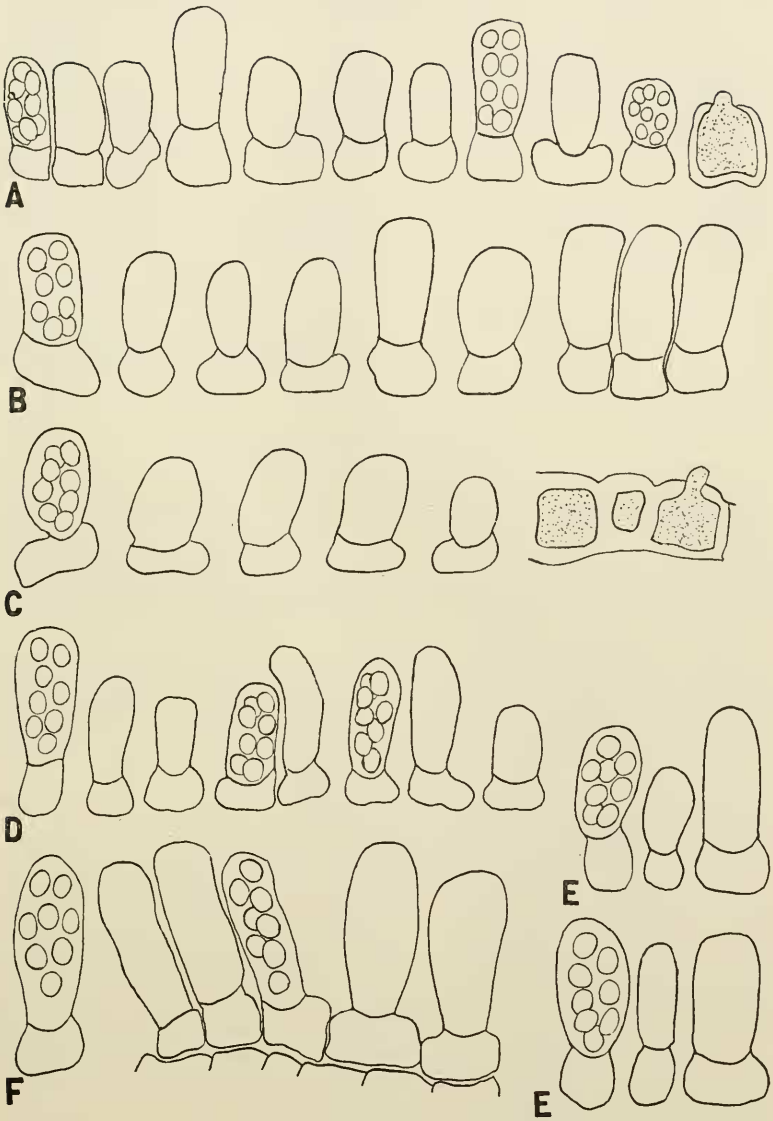

Fig. 36. A, asci, ascus emerging from chlamydospore of *Taphrina acerina;* B. asci of *T. acericola;* C, asci, chlamydospores, and emerging ascus of *T. acericola* (*T. jaczewski*); D. asci of *T. sacchari;* E, *T. pseudoplatani;* F, *T. bartholomaei.* All × 900.

1895 (Ex. Herb. C. Massal.). As *T. jaczewski.* RUSSIA: Trancaucasia, Kedanah, July, 1890 (part of type); Central Russia, June 13, 1913, N. Troussova (Herb. Inst. Mycol. et Phytopath. Jaczewski).

Jaczewski (1901) distinguished *Exoascus confusus* from *Taphrina acericola* by the fact that its mycelium is perennial in the branches and induces witches' brooms. The type material shows only small spots on leaves (quite like those caused by *T. acericola*), but assuming that Jaczewski is correct, the formation of witches' brooms would be insufficient ground for separation of this fungus from *T. acericola,* when the two are morphologically indistinguishable.

This fungus is very similar to *Taphrina acerina,* the asci of the two forms being nearly alike in size and shape. In both fungi the ascus emerges from the chlamydospore by rupture of the chlamydospore wall. Both are reported as causing witches' brooms. It is possible that they are the same species.

86. *Taphrina sacchari* Jenkins

Taphrina sacchari Jenkins, Jour. Wash. Acad. Sci. 28:8:353-358. 1938.

Causing small, round to irregular, brownish marginal spots, which may coalesce to form blighted areas extending inward between main veins, on leaves of *Acer saccharum* Marsh., and *A. migrum* Michx.

Mycelium subcuticular.

Asci hypophyllous, often scattered, in places close packed, short-cylindric, rounded at the apex; stalk cells short and broad, sometimes broader than the ascus. Ascospores eight, round, ovate, or elliptic, often budding in the ascus. (Fig. 36, D.)

Dimensions: Of *asci,* 13-30μ × 6-13μ; of *stalk cells,* 5-13μ × 8-20μ; of *ascospores,* 3.5-6μ × 3-5μ.

Distribution: eastern and central North America.

Material examined: Acer saccharum. ARKANSAS: Fayetteville, May 2 and May 5, 1935, V. H. Young; *ibid.,* June, 1935, J. C. Dunegan; *ibid.,* May 21, 1937, V. H. Young; *ibid.,* May 8, 1940, *id.; ibid.,* May 24, 1941, J. C. Dunegan and A. J. M.; Mountainburg, May 25, 1941, A. J. M. KANSAS: Independence, May 11, 1944, G. W. Stafford. MAINE: Rockport, June 26, 1922, J. Achorn (U. S. D. A. Path. and Myc. Coll. 68554). PENNSYLVANIA: Williamsport, June 17, 1935, R. S. Kirby (from L. O. Overholts).

Jenkins (1938) in describing *Taphrina sacchari* mentioned its close similarity to *T. acericola* but considered that she had evidence of a biological difference between the two. The morphological similarity is indeed very close and it may be that the two species are identical. They are here treated as separate species because of differences in host relationships and geographic distribution.

887. *Taphrina bartholomaei* nomen novum

Taphrina bartholomaei nomen novum.
T. aceris (Dearn. and Barth.) Mix, Univ. Kansas Sci. Bull. 24:10:151-176. 1936.
Exoascus aceris Dearn. and Barth. (Dearness, Mycologia 9:345-364. 1917.)

Causing small (ca. 5-10 mm. diam.), brown, unthickened, necrotic spots on leaves of *Acer grandidentatum* Nutt.

Mycelium subcuticular.

Asci hypophyllous, epiphyllous, or amphigenous, short-cylindric, rounded at the apex; stalk cell short, often broader than the ascus. Ascospores eight, round, ovate, or elliptic, often budding in the ascus. (Fig. 36, F.)

Dimensions: Of *asci,* 20-40μ × 8-13μ; of *stalk cells,* 7-17μ × 7-17μ; of *ascospores,* 4-5.5μ × 3.5-4.5μ.

Distribution: Utah.

Material examined: Utah: Salt Lake Co., Parley's Canyon, June 29, 1915, Bartholomew and Garrett (F. Columb. 5018).

The name *Exoascus aceris* applied to this fungus by Dearness, and the new combination made by Mix (1936a) are invalid, since Fisch (1885) had described a fungus on *Acer platanoides* as *Exoascus aceris* Linhart. This fungus was declared identical with *Taphrina polyspora* Sorok. by Johanson (1886).

In renaming this fungus it would have been desirable to honor Dearness but that had been done by Jenkins (1939) in naming a fungus on *Acer rubrum.* The species is therefore named after Bartholomew, who took part in its collection.

88. *Taphrina pseudoplatani* (Massal.) Jaap

Taphrina pseudoplatani (Massal.) Jaap, Ann. Mycol. 15:97-124. 1917.
Taphrina polyspora (Sorok.) Johans. var. *pseudoplatani* Massalongo, Bull. Soc. Bot. Ital. 1892:197-199.
T. acericola (Massal.) var. *pseudoplatani* Massalongo, Malpighia 8:97-130. 1894.

Causing irregular, unthickened, gray to blackish spots (0.5 to 1 cm. diam.) with indefinite margin, on leaves of *Acer pseudoplatanus* L.

Mycelium subcuticular.

Asci hypophyllous, short-cylindric, rounded at apex, stalk cell short, usually not wider than the ascus. Ascospores eight, round, ovate, or elliptic, often budding in the ascus. (Fig. 36, E.)

Dimensions: Of *asci,* 13-26μ × 8-13μ; of *stalk cells,* 6-13μ × 8-13μ; of *ascospores,* 4-5.5μ × 3.5-4.5μ.

Distribution: Italy, Switzerland.

Material examined: Switzerland: near Grindelwald, Aug. 3,

1910, O. Jaap. No locality, date or collector (Herb. C. Massalongo and Ex Herb. Bresadola in Bot. Mus. Stockholm).

This fungus seems very close to *Taphrina acericola,* from which it is distinguished by its narrower stalk cell. It is significant that both fungi occur in Italy. Perhaps further study will show them to be identical.

89. *Taphrina polyspora* (Sorok.) Johanson

Taphrina polyspora (Sorok.) Johanson, Ofvers. of K. Svensk. Vetensk. Akad. Forhandl. **1885**:29-47. 1886.
Ascomyces polysporus Sorokin, Ann. Sci. Nat. 6 ser. Bot. **4**:72. 1876.
Exoascus aceris Linhart, Fungi Hungarici (Fisch, Bot. Centbl. **22**:126-127. 1885).

Causing small (ca. 1 cm. diam.) roundish spots or larger irregular areas, blackish, unthickened, on leaves of *Acer. orientale* L. and *A. tataricum* L.

Mycelium subcuticular.

Asci hypophyllous, short-cylindric, rounded at the apex, often widened at the base forming a fairly definite foot, lacking a stalk cell. Ascospores eight, round, ovate, or elliptic, budding at once and filling the asci with small round to elliptic blastospores. (Fig. 37, A.)

Dimensions: Of *asci,* 26-60μ × 8-23μ; of *ascospores,* 4.5-5μ × 4-4.5μ; of *blastospores,* 2-4μ × 2-4μ, or smaller.

Distribution: Europe.

Material examined: A. orientale. GREECE: Messenie, Selitsa, Mt. Taygetos, April 24, 1908, R. Maire (Mission Bot. Orient, 1908, 3,200.). *A. tataricum.* GERMANY: Bavaria, Freising, Garden of Lyceum, June, 1902, J. E. Weiss (Myc. Germ. 173). RUSSIA: Petropolitana, Peterhof, A. Jaczewski (Cornell Univ. Dept. Plant Path. 17092). SWEDEN: Uppland, Uppsala, June, 1884, C. J. Johanson.

90. *Taphrina letifera* (Pk.) Saccardo

Taphrina letifera (Pk.) Saccardo, Sylloge Fungorum **10**:67.
Ascomyces letifer Peck, New York State Mus. Nat. Hist. Ann. Rept. **40**: 39-77. 1887.

Causing large, indefinitely margined spots on leaves or blighting whole leaves of *Acer spicatum* Lam. Spots when fresh may be green or reddened, but in dried specimens are black.

Mycelium intercellular.

Asci hypophyllous or amphigenous, broad-cylindric, rounded or truncate at the apex; stalk cell short, frequently wider than the ascus. Ascospores eight, round, ovate, or elliptic, often budding in the ascus. (Fig. 37, B, C.)

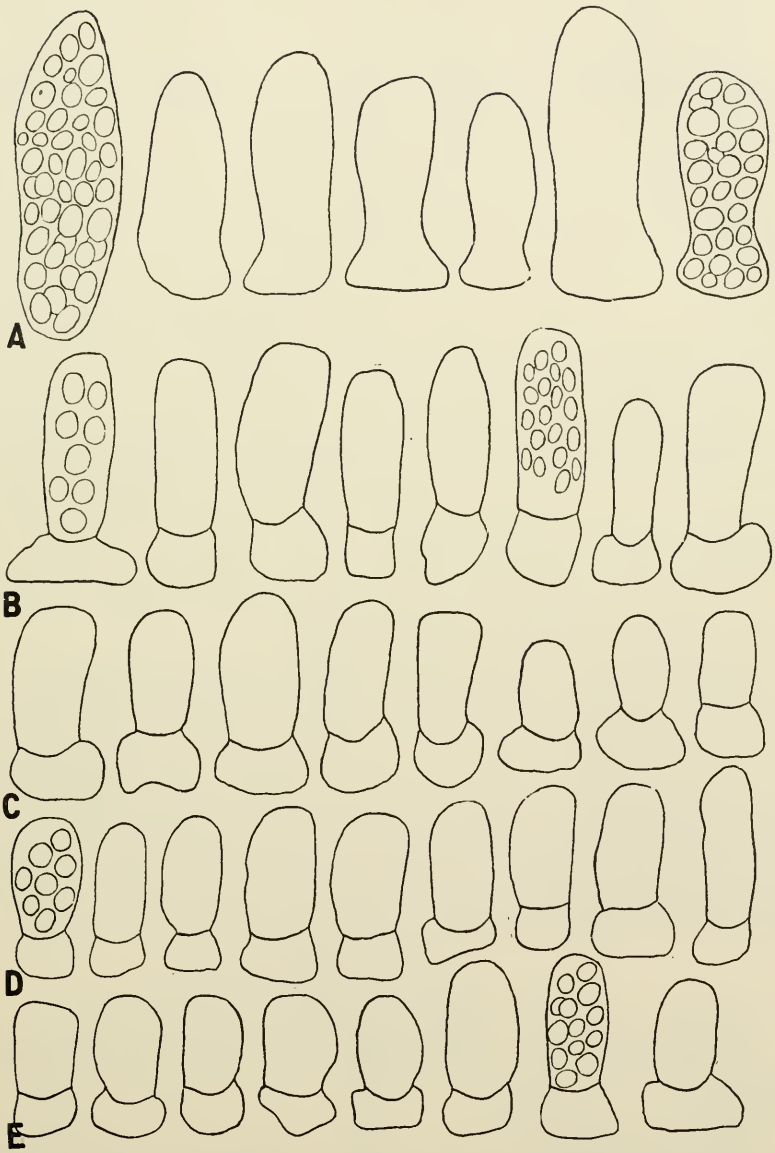

Fig. 37. Asci (× 900) of A, *Taphrina polyspora;* B, C, *T. letifera;* D, E, *T. darkeri.*

Dimensions: Of *asci,* 14-35μ × 8-18μ; of *stalk cells,* 6-13μ × 8-25μ; of *spores,* 4-5μ × 4-5μ.

Distribution: eastern North America.

Material examined: MASSACHUSETTS: Mt. Wachusett, June 12, 1936, G. D. Darker. MINNESOTA: Bear River, Big Bear Lake, June 28, 1947, A. J. M. NEW YORK: Elizabethtown, June, 1886, C. H. Peck (part of type); Labrador Lake, near Apulia, June 25, 1940, A. J. M. NORTH CAROLINA: Nantahala Gorge, May 29, 1941, *id.*

Peck's measurements of this fungus are in decimal fractions of inches. When converted into millimeters they become: Asci, 40-50μ × 15-20μ. Examination of Peck's type material shows these measurements to be wrong. They would not be so far wrong if Peck had been considering the whole ascus, including the stalk cell. He makes no mention of the stalk cell.

Jenkins (1938) gives dimensions of asci as 36-50μ × 14-20μ, of stalk cells as 14-20μ × 17-25μ. Careful study of the type material as well as of other specimens mentioned above has revealed no asci so large as these. Asci on the lower surface of the leaf are regularly smaller than those on the upper.

Peck spelled his species name "letifer." Saccardo inserted an "h" in renaming the fungus *Taphrina lethifera.* As "letifer" is good Latin, Saccardo's change was unnecessary.

Jenkins and Ray (1940) have assigned the fungus collected by them on *Acer spicatum* at Labrador Lake to *Taphrina dearnessii* on the basis of similarity of host lesions and size of asci. Material collected at Labrador Lake by the writer agrees in all respects with *Taphrina letifera.* It may be that *Taphrina dearnessii* and *T. letifera* will prove to be one and the same species; the two fungi were found abundantly in the same locality (Bear River, Minn.) in 1947. In any event convincing evidence that two distinct species of *Taphrina* occur on *Acer spicatum* is lacking.

91. *Taphrina darkeri* Mix

Taphrina darkeri Mix, Trans. Kansas Acad. Sci. **50**:77-83. 1947.

Causing small brown necrotic spots on leaves of *Acer circinatum* Pursh.

Mycelium intercellular.

Asci amphigenous, broad-cylindric, rounded or truncate at the apex; stalk cell short, often wider than the ascus; ascospores eight, round, ovate, or elliptic, frequently budding in the ascus. (Fig. 37, D, E.)

Dimensions: Of *asci,* 16-33μ × 8-13μ; of *stalk cells,* 5-12μ × 10-17μ; of *spores,* 4-4.5μ × 3.5-4μ.

Distribution: Oregon.

Material examined: Oregon: Oregon Caves, head of Limestone Creek, Aug. 15, 1929, G. D. Darker (Herb. Arnold Arboretum 5077).

92. *Taphrina nikkoensis* Kusano

Taphrina nikkoensis Kusano, Bot. Mag. Tokyo. **21**:65-67. 1907.
Exoascus nikkoensis (Kus.) Saccardo, Sylloge Fungorum **22**:763.

Causing small (ca. 5 mm. diam.) round to irregular, yellowish, unthickened spots, or larger blighted areas on leaves of *Acer diabolicum* K. Koch. var. *purpurascens* Rehd.

Mycelium subcuticular.

Asci hypophyllous, cylindric, with rounded apex, rather variable in size and shape; stalk cell no wider than the ascus. Ascospores eight, round, ovate, or elliptic, often budding in the ascus. (Fig. 38, A.)

Dimensions: Of *asci,* 20-50μ × 8-13μ; of *stalk cells,* 8-15μ × 7-13μ; of *spores,* 4-6μ × 3.5-5μ.

Distribution: Japan.

Material examined: Japan: Nikko, May 27, 1906, S. Kusano (Received from Kusano, presumably part of type).

93. *Taphrina dearnessii* Jenkins

Taphrina dearnessii Jenkins, Jour. Washington Acad. Sci. **29**:222-230. 1939.

Causing small, well defined dark brown to black, unthickened spots, sometimes coalescing to involve large areas of the leaf-blade, on leaves of *Acer rubrum* L.

Mycelium subcuticular.

Asci amphigenous, short-cylindric, rounded or truncate at the apex, stalk cell short, often broader than the ascus. Ascospores eight, round to elliptic, often budding in the ascus. (Fig. 38, B.)

Dimensions: Of *asci,* 17-35μ × 8-17μ; of *stalk cells,* 6-13μ × 10-23μ; of *ascospores,* 4.5-6μ × 3-5μ.

Distribution: eastern North America.

Material examined: Michigan: Indian River, July 1, 1947, A. J. M.; between Isabella and Cooke, July 1, 1947, *id.* Minnesota: Bear River, Big Bear Lake, June 29, 1947, A. J. M.; Janet Lake, 28 mi. N. of Floodwood, July 1, 1947, *id.* New York: Ithaca, Ringwood Preserve, June 11, 1940, A. J. M. North Carolina: Nantahala Gorge, May 29, 1941, *id.* Virginia: Halifax Co., Nathalie, May 13, 1935, E. R. Mickle. Quebec: Davidson, June, 1938, I. L. Connors.

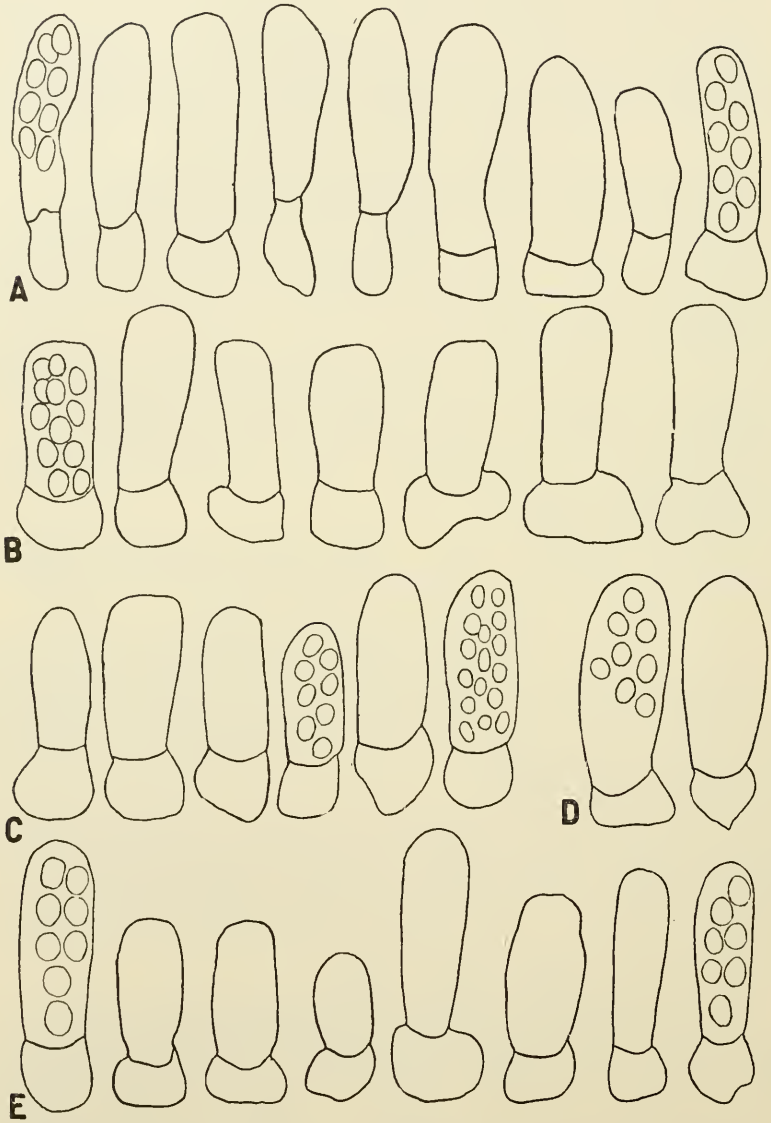

FIG. 38. Asci (× 900) of A, *Taphrina nikkoensis;* B, *T. dearnessii;* C, *T. carveri;* D, *T. sebastianae;* E, *T. aesculi.*

94. *Taphrina carveri* Jenkins

Taphrina carveri Jenkins, Jour. Washington Acad. Sci. **29**:222-230. 1939.

Causing small, well defined black spots on leaves of *Acer saccharinum* L.

Mycelium subcuticular.

Asci hypophyllous, short-cylindric, rounded or truncate at the apex; stalk cells short, often broader than the ascus. Ascospores eight, round, ovate or elliptic, often budding in the ascus. (Fig. 38, C.)

Dimensions: Of *asci,* 23-53μ × 8-17μ; of *stalk cells,* 4-15μ × 10-22μ; of *spores,* 4.5-6μ × 3-5μ.

Distribution: Alabama, Missouri.

Material examined: ALABAMA: Tuskegee, April 30, 1897 (Ellis Herb. 17918). MISSOURI: Lutesville, May 30, 1941, A. J. M.; *ibid.,* June 3, 1942, L. Engelhart.

This fungus is very close indeed to *Taphrina dearnessii* on *Acer rubrum.* Perhaps the two species are identical.

HOST INDEX TO SPECIES OF *TAPHRINA* ON ACER

Acer campestre L.
  Taphrina acericola Massal.
Acer circinatum Pursh.
  Taphrina darkeri Mix
Acer diabolicum K. Koch. var. *purpurascens* Rehd.
  Taphrina nikkoensis Kus.
Acer grandidentatum Nutt.
  Taphrina bartholomaei (Dearn. and Barth.) Mix
Acer nigrum Michx.
  Taphrina sacchari Jenkins
Acer orientale L.
  Taphrina polyspora (Sorok.) Johans.
Acer platanoides L.
  Taphrina acerina Eliass.
Acer pseudoplatanus L.
  Taphrina pseudoplatani (Massal.) Jaap
Acer rubrum L.
  Taphrina dearnessii Jenkins
Acer saccharum Marsh.
  Taphrina sacchari Jenkins
Acer saccharinum L.
  Taphrina carveri Jenkins
Acer spicatum Lam.
  Taphrina letifera (Pk.) Sacc.
Acer tataricum L.
  Taphrina polyspora (Sorok.) Johans.

IX. SPECIES ON HIPPOCASTANACEAE

Aesculus

95. *Taphrina aesculi* (Patt.) Giesenhagen

Taphrina aesculi (Patt.) Giesenhagen, Flora **81**:267-361. 1895.
Exoascus aesculi Patterson, Bull. Lab. Nat. Hist. Univ. Iowa **3**:89-135. 1895.

Causing small to large, round to irregular, yellow-brown blighted areas on leaves of *Aesculus californica* Nutt. Affecting whole shoots and shoot-systems. Specimens seen have not been true witches' brooms.

Mycelium intercellular, in leaves and twigs.

Asci hypophyllous, epiphyllous, or amphigenous, rounded at the apex, stalk cell short, sometimes wider than the ascus. Ascospores eight, round, ovate, or elliptic, often budding in the ascus. (Fig. 38, E.)

Dimensions: Of *asci,* 20-38μ × 8-15μ; of *stalk cells,* 7-13μ × 10-23μ; of *spores,* 4-7μ × 4-5.5μ.

Distribution: California.

Material examined: CALIFORNIA: Glenn Co., near Elk Creek, May 15, 1938, H. Earl Thomas; Hopland, May 13, 1936, *id.;* Marin Co., Muir Woods, May 25, 1929, L. Bonar; Palo Alto, San Francisquito Creek, April 25, 1940, R. H. Thompson; *ibid.,* May 1, 1940, *id.; ibid.,* May 13, 1941, *id.*

X. SPECIES ON COMPOSITAE

Sebastiana

96. *Taphrina sebastianae* (Sadeb.) Jaczewski

Taphrina sebastianae (Sadeb.) Jaczewski, Pocket Key for Determination of Fungi. Part I. Exoascales. Leningrad. 1926.
Exoascus sebastianae Sadebeck, Ber. Deutsch. Bot. Ges. **22**:119-133. 1904.

Causing lesions whose nature cannot be determined from extant material (because of the presence of a rust-fungus) on leaves of *Sebastiana ypanemensis* (Mill.) Arg.

Mycelium of unknown habit.

Asci cylindric, rounded at the apex, stalk cells flattened or wedge-shaped below. Ascospores eight, round, ovate, or elliptic, often budding in the ascus. (Fig. 38, D.)

Dimensions: Of *asci,* 26-40μ × 13-18μ; of *stalk cells,* 7-13μ × 13-18μ; of *blastospores,* 4-5.5μ × 2-4μ.

Distribution: Brazil.

Material examined: Brazil: Santa Catharina, Tubarao, Nov. 1889, E. Ule [three collections: 1. E. Ule, Fungi botanicum Berolinense 1496, Type. 2. Ex. Herb. Sydow (in Bot. Mus Stockholm). 3. Herbarium Brasiliense 1495 (in Farl. Herb.)].

Sadebeck (1904), in describing this fungus, recorded a remarkable polymorphism of asci. All of the curious asci described and figured by him were apparently teliospores of a rust. They occur in all states: immature, mature, and germinating. The rust is abundant in all specimens examined and in the type specimens no asci are to be found. The asci were seen best in the specimens in the Stockholm Museum. They are typical *Taphrina*-asci as described above. Further collections of this fungus would be very desirable.

The labels of the type-collection and of the specimens in the Farlow Herbarium read: "*Exoascus Sebastianae* Sadeb. n. sp., *Uredo Sebastianae* Wint. n. sp."

XI. SPECIES ON ZINGIBERACEAE

Curcuma, Globba, Hedychium, Zingiber

97. *Taphrina maculans* Butler

Taphrina maculans Butler, Ann. Mycol. 9:36-39. 1911.

Causing small (up to 5 mm. diam.) yellow-brown, unthickened spots, (very numerous and crowded) on leaves of *Curcuma amada* Roxb., *C. angustifolia* Roxb., *C. longa* L., *Hedychium acuminatum* Wall., *Zingiber casumunar* Roxb., *Z. mioga* Rosc., *Z. berumbet* Rosc.

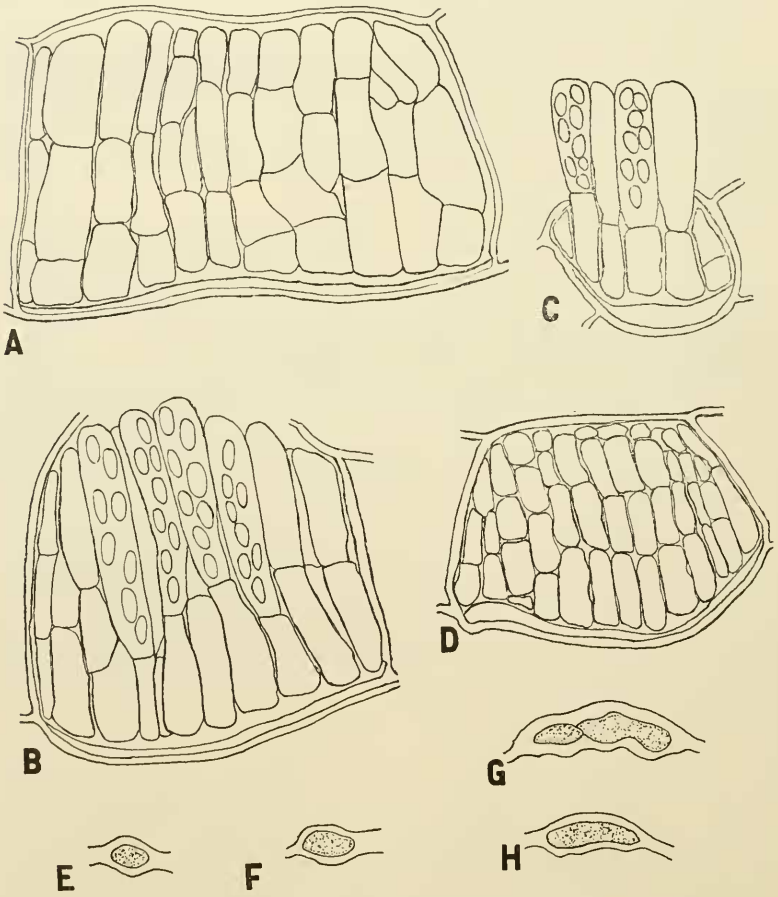

FIG. 39. A, ascogenous cells; B, asci of *Taphrina maculans;* C, asci; D, ascogenous cells of *T. linearis.* E-H, mycelium of *T. linearis* growing in the epidermal wall. All × 900.

Mycelium growing within epidermal walls and within radial walls between cells of epidermal and subepidermal layers, sometimes forming flat plates of hyphae, occasionally sending haustoria into host cells. (Fig. 39, A, C.)

Asci epiphyllous, clavate, rounded or truncate at the apex; stalk cell single or divided by septa into two or three cells; ascospores eight, round, ovate, or elliptic, sometimes budding in the ascus.

Dimensions: Of *asci,* 20-36μ × 6-10μ; of *stalk cells,* 10-17μ × 5-7μ; of *ascospores,* 4-6.5μ × 2-3.5μ.

Distribution: India, Japan.

Material examined: Curcuma amada. India: Sahranpur, Government Bot. Gardens, Nov. 17, 1903, W. Gollan.

C. angustifolia. Himalaya: Kumaon, Bageshwar, June 13, 1907, Inayat Khan.

C. longa. Bihar: Pusa, Aug., 1916, M. Taslim. Bombay Pres.: Hatkalangda, Dec. 15, 1910, G. S. Kulkarni.

Hedychium acuminatum. India: Nainital and Musscorie, Oct. 6, 1929, J. H. Mitter, A. K. Mitra, V. B. Singh.

Zingiber casumunar. India: Bengal, Rangpur, March 13, 1909, S. N. Mitra.

Z. mioga. Japan: Mutsu, Korekawa, Oct. 1, 1913, M. Miuma (Herb. Sydow, Bot. Mus. Stockholm).

Z. zerumbet. India: Bihar, Muzaffarpur, Awapur, Oct. 18, 1910, Jamal bux.

Most of these specimens are immature, and only rarely may mature asci be found.

98. *Taphrina linearis* Sydow and Sydow

Taphrina linearis Sydow and Sydow, Ann. Mycol. 12:545-576. 1914.

Causing small, elongate, red-brown spots or streaks on leaves of *Globba marantina* L.

Mycelium growing within the outer epidermal wall and within radial walls between cells of epidermal and hypodermal layers.

Asci clavate, rounded or truncate at the apex, each provided with one or a few stalk cells. (Fig. 39, B, D-H.)

Dimensions: Of *asci,* given by the authors as 25μ × 7-9μ; a few young asci seen by the writer measured 13-20μ × 6-8μ; of *ascospores,* 4-5μ × 3.5-4μ.

Distribution: Philippine Islands.

Material examined: Philippine Islands: Luzon, Bulacan, near Angat, Sept. 15, 1913, M. Ramos (F. Exot. Exs. 422. Three copies seen).

This material is, for the most part, immature.

XII. NONVALID AND EXCLUDED SPECIES

A. Described Species

1. *Exoascus anomalus* Saccardo, Sylloge Fungorum 8:820.
This is *Ascocorticium anomalum* Schroet.

2. *Taphrina candicans* Saccardo, Michelia 1:117-132. 1880.

This "fungus" was described by Saccardo as a doubtful species of *Taphrina* occurring on *Teucrium chamaedrys* L. A specimen exists in the Botanical Museum at Padua, and duplicates were issued (collected at Lyon, 1884) under this name as Roumeguére, Fungi selecti exsiccati 4499. The species was excluded from the genus by Giessenhagen (1895) and the specimen is said by Jaczewski (1926) to show the effect of mite-injury and no fungus.

3. *Taphrina cissi* Zollinger, Natur. et Genneeskund. Arch. Nederlands Indie 1:372-405, 2:1-19, 200-273, 563-587, 3:51-92. 1847.

This fungus was described as occurring on *Cissus varius*. A record and description of it is to be found in the Botanical Museum at Buitenzorg, but no specimen is known. It is not mentioned in the literature since Zollinger except for a copy of Zollinger's description in Saccardo, Sylloge Fungorum **10**:68.

4. *Ascomyces fulgens* Cooke and Harkness, Grevillea 9:6-9. 1880.
Exoascus fulgens (Cke. and Harkn.) Saccardo, Sylloge Fungorum 8:820.

This "fungus" was described by Cooke and Harkness as occurring on leaves of *Arctostaphylus pungens* HBK. It was later pronounced by Harkness (1886) to be an "aphidian gall."

5. *Exoascus marginatus* Lambotte and Fautrey. (Roumeguere, Fungi Exsicati Praecipue Gallici, 6228.)

This was described as occurring on leaves of *Crataegus oxyacantha* L. The specimens, collected Aug. 1892 by F. Fautrey, show only injury due to mites (Erineum).

6. *Taphrina rhaetica* Volkart, Ber. Deutsch. Bot. Ges. 21:477-481. 1903.

This fungus, described by Volkart as occurring on leaves of *Crepis blattarioides* Vill., was transferred by Juel (1902) to the genus *Taphridium* of the Protomycetaceae becoming *Taphridium volkartii* (Volkart) Juel.

7. *Taphrina umbelliferarum* Rostrup, Bot. Tidskr. 14:230-243. 1885.

The fungus, described by Rostrup as occurring on *Heracleum sphondylium* L. and *Peucedanum palustre* Moench., was transferred by Juel (1902) to the genus Taphridium, becoming *Taphridium umbelliferarum* (Rostr.) Lagerh. and Juel.

8. *Taphrina oreoselini* Massalongo, Nuov. Giorn. Bot. Ital. **21**:422-423. 1889.

Occurring on *Peucedanum oreoselinum* Moench., this fungus is apparently identical with the preceding and was renamed by Juel (l. c.) *Taphridium umbelliferarum.*

9. *Taphrina githaginis* Rostrup, Vidensk. Meddel. Natursk. Foren. Kjøbenhavn. **1890**:246-264. 1890.

This fungus, on *Agrostemma githago* L., from its description clearly belongs to *Taphridium.* Neger (1905) proposes its transfer to that genus, without, however, actually renaming it. Specimens have not been seen.

10. *Exoascus avellanae* Connold, Plant Galls of Great Britain. London. 1909.
Exoascus coryli Lemée, Bull. Soc. Hort. del Orne, Alencon. 1917.

No fungus having been seen in association with this witches' broom of *Corylus avellana,* Saccardo (Sylloge Fungorum **24**:1301) declared this binomial to be a nomen nudum.

11. *Taphrina randiae* Rehm, Hedwigia **40**:170. 1901.

This species, occurring on *Randia* sp., was named and described from a specimen collected at Serra Orgãos, Brazil, by E. Ule. It was reported as causing elliptic (1-2 cm. × 1.5-1 cm.) black spots thickened above. The asci were said to measure 50μ × 25μ, to lack a stalk cell, and to be polysporous. A portion of the type-specimen was received from the Berlin Botanical Museum as a gift. It consisted of part of a leaf which had been cut in two, the cut passing through a thickened black spot which appeared as described above. This spot contained acervuli but no asci. No mycelium characteristic of *Taphrina* could be found. The name *Taphrina randiae* thus becomes a *nomen dubium.* No attempt was made to identify the imperfect fungus.

12. *Exoascus uleanus* F. Hemmings, Hedwigia **43**:79-95. 1904.

This species has been fully discussed earlier in the section dealing with forms on ferns. As pointed out there no identifiable fungus can be found, either in the type specimen or in duplicates. The binomial becomes a *nomen dubium.*

13. *Exoascus theobromae* Ritzema Bos, Tijdschr. Plantenziekt. **6**:65-90. 1900.

In this paper Ritzema Bos described a witches' broom of *Theobroma cacao* L. occurring in Surinam. He stated that he found a few asci present, but could not, on account of the state of the material describe the fungus. Nevertheless he named it as above. Went (1904) studied the same material, finding mycelium present

but no asci, and was unable to decide whether the witches' broom was due to a species of *Taphrina*. Subsequently Faber (1908) declared *Exoascus theobromae* to be a *nomen nudum*.

According to Cook (1913) the witches' broom of cacao, said by Ritzema Bos to be caused by *Exoascus theobromae*, was later ascribed by Van Hall and Dorst to *Colletotrichum luxificum*.

14. *Taphrina bussei* Faber, Arb. K. Biol. Anst. Land und Forstw. 6:385-395. 1908.

This fungus was described by Faber as causing a witches' broom on *Theobroma cacao* L. The disease was found in Kamerun, and was held to be distinct from the witches' broom of Surinam (see above). The fungus was said to have asci 15-17μ × 5μ and spores 2.5μ × 1.7μ. No mention was made of a stalk cell but the asci shown in Faber's figure seem to be borne on the ends of septate hyphae. The fine mycelium described and figured is intracellular.

This fungus has not received further mention in the literature. Dr. von Schoenau, then chief curator of the Munich Botanical Museum, wrote in 1938 that he had been informed by Faber that the type-material of *Taphrina bussei* had been placed in the herbarium of the Biologische Reichsanstalt für Land-und Forstwistschaft in Berlin, but that a thorough search instituted there in response to his inquiry had failed to reveal it.

According to Ludwigs (1934), this witches' broom (which should be rather called "overbranching") is due to adverse environmental factors and not to any parasite.

B. Species named but never described

1. *Exoascus quercus-lobatae* Mayr, Die Waldungen von Nordamerika etc. Munich. 1889.

This name, unaccompanied by any description, was given to a supposed fungus causing a witches' broom on *Quercus lobata* Née. It is clear from Mayr's account that he never saw any fungus and the cause of the witches' broom remains unknown. *Taphrina caerulescens* does occur on this host.

2. *Taphrina fagi* Lamb. (See account given earlier in this paper.)

3. "*Exoascus* or *Taphrina*" on Fuschia. São Leopoldo, Rio Grande do Sul. 1905. Rick, Fungi Austro Americani 78.

Three packets of this collection are in the Farlow Herbarium, two of them from the herbarium of F. Theissen. No *Taphrina* is present.

4. "*Exoascus Taphrina in Myrtacea.*" São Leopoldo, Rio Grande do Sul, 1929. Rick, Expeditions in Brazil. In Farlow Herbarium.

These specimens have an appearance suggesting mite injury. No *Taphrina* is present.

5. "*Exoascus Tradescantiae,*" São Leopoldo, Rio Grande do Sul. Rick, Expeditions in Brazil. In Farlow Herbarium.
Acervuli are present, but no *Taphrina*.

6. "*Exoascus Symploci* E. and E." on *Symplocus tinctoria,* Coöpolis, Mississippi, April 24, 1898. S. M. Tracy. Farlow Herbarium, 5326, Herb. S. M. Tracy.

Specimens are of greatly deformed structures, perhaps fruits. A fungus is present but is not determinable.

7. "*Taphrina selaginellae* P. Hennings ad int." on *Selaginella menziesii* Hook. and Gr., Hawaii: Molokai, Pali of Kalanpapa from Kalae. W. Hillebrand. In Mus. Bot. Berlin (in 1938).

This fungus is mentioned by Laubert (1928). Specimens obtained from the Berlin Museum consisted of one healthy and one diseased shoot. The latter was dwarfed, with closely appressed, partially developed scales. It was pale green to brownish and bore a number of small brown spots covered with a white bloom. The fungus present was a Hyphomycete with spores about the size of those of *Taphrina*. No asci could be found and the slender hyphae were intracellular.

8. "*Exoascus* sp., Taches bullaties sulres feuilles de *Alnus acuminata* o' *A. ferruginea* are Carrio Amon a' San Jose." Jan., 1913. A. Tonduz. Mus. Nac. de Costa Rica 164. In Farlow Herbarium.
Perhaps insect injury. No *Taphrina*.

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